OVERVIEW ECONOMIC ASSESSMENT OF REMEDIAL ACTION PLANS FOR THE GREAT LAKES' AREAS OF CONCERN

includes some general RAP stuff

APRIL 1990

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OVERVIEW ECONOMIC ASSESSMENT OF REMEDIAL ACTION PLANS FOR THE GREAT LAKES' AREAS OF CONCERN

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Remedial Action Plan
Plan d'Assainissement

Steering Committee

Preface

"Overview Economic Assessment of Remedial Action Plans"

The Remedial Action Plan Program commenced in 1986 with the establishment of the federal-provincial Remedial Action Plan (RAP) Steering Committee and seventeen RAP Teams under the Review Board for the Canada-Ontario Agreement Respecting Great Lakes Water Quality.

Since that time, Public Advisory Committees have been established at RAP sites and progress has been made in describing environmental conditions, identifying pollution sources, defining use impairments, and setting goals for remediation. Several RAPs are now in the process of selecting preferred options and the program is entering a critical phase of transition from plan development to obtaining commitments for plan implementation. Recognizing the importance of this transition, the Policy and Planning Branch of Environment Ontario, under the auspices of the RAP Steering Committee, undertook the attached "Overview Economic Assessment of Remedial Action Plans".

The intent of this study is twofold: first, to provide a general framework for economic assessment of RAPs and, second, to provide a preliminary indication of the costs and benefits which may be associated with implementation of the overall RAP program. Given that each RAP is at a different stage of development, it was necessary to make certain underlying assumptions consistent across the entire program. It is expected that further site-specific assessments, reflecting locally defined goals and preferred remedial options, will be conducted and incorporated into the individual RAPs by the RAP Teams and Public Advisory Committees. This study provides a general framework for undertaking these more detailed assessments.

The RAP Steering Committee views this study as an important supporting document in moving the program from plan development to implementation.

Canada Ontario
Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs

TABLE OF CONTENTS

TABLE OF CONTENTS
(cont'd)

Purpose

Canada and the U.S. signed in 1987 an amendment to the Great Lakes Water Quality Agreement specifying, among other things, the preparation of Remedial Action Plans (RAPs) for the Areas of Concern that had been designated by the International Joint Commission.

The purpose of this study was two-fold:

- to provide estimates of the orders of magnitudes of the benefits and costs of restoring the beneficial uses of the 17 Areas of Concern in the Great Lakes identified by the International Joint Commission (IJC). These 17 Areas of Concern are either on the Ontario side of the lakes or are shared with the U.S; and

- to develop a general framework for studying costs and benefits by describing the steps involved in estimating the costs and benefits for these remedial actions.

The results of the study are intended to be used in the overall planning of the RAP program, and not for estimating the detailed costs and benefits for each of the RAP sites.

SCOPE AND METHODOLOGY

This study was the first-ever attempt to estimate the orders of magnitude for the costs and benefits of the RAP clean-ups as a group. A number of decisions were made on the scope of the work and the methods to be used. These decisions, summarized below, must be understood if the results of the study are to be appreciated.

estimating overall costs and benefits

The costs and benefits calculated in this report represent order-of-magnitude estimates. That is, the estimates give a sense of the extent of the costs and likely effects of the whole RAP program. Costs and benefits were derived on a site-specific basis, for each of the 17 sites, and then summed to present the

overall totals. In the case of the economic value estimates, two target areas were assumed - one consisting of all 17 of the RAP sites, and one designated as the Province as a whole. Estimates of economic impact were calculated only for Ontario in total, primarily because income and employment multipliers are more reliable at the Provincial levels than they are at a regional or local level.

standard water quality objectives

The individual RAP teams, together with input from Public Advisory Committees, are formulating remedial action plans based on selected water use goals for their local water body. To make this study manageable, a standard set of water quality objectives was selected to be used at all sites as opposed to carrying out a detailed analysis of each of the sites. The water quality objectives used were water which was:

- aesthetically pleasing;
- swimmable;
- able to support an edible fishery; and
- able to support a self-sustaining sportfishery.

Technical criteria were then set for determining whether a water body was in accord with these objectives.

These water quality objectives were believed to be representative of the objectives being examined by the individual RAP teams, but the set is not intended to be exhaustive nor to preclude choice. Other water quality objectives such as the development of commercial fishing are being examined by some of the RAP teams.

This selection of a standard set of water quality objectives led to one particularly important issue. At some of the sites, the technical water quality criteria set for this study (as noted in exhibit 3.1) were not met. Thus, remedial plans were prepared and costed. However, in some cases some of the local users of the water body did not agree that the water quality objectives were in fact impaired. The fact that remedial measures have been costed in these cases does not imply that the study has pre-empted decisions about water impairments or remedial measures at the RAP sites. The purpose of this approach was to ensure consistency across all 17 sites. In practice, the appropriate authorities would probably not take remedial actions which were not deemed beneficial by the ultimate users of the water body.

sources of pollution

The study considered six sources of pollution as potentially contributing to the water quality impairment at the RAP sites:

- sewage treatment plants;
- urban runoff;
- agricultural runoff;
- toxic wastes of industries;
- contaminated sediment; and
- leakage from existing toxic waste sites.

A seventh source of pollution in the Great Lakes, namely airborne deposition, has also been identified. That source has not been counted in this analysis, primarily because so little is known about it.

remediation costs

The costs of remediating a particular site were calculated by first determining the sources of pollution present at that site and then costing the appropriate remedial actions. Details of the remedial actions considered for each of these sources of pollution are presented in the report and the appendices.

Not all remediation costs could be counted. The consultants estimated the costs that were judged to account for the majority of the likely costs of remediation. For example: costs of on-going monitoring for compliance and for testing of the water quality objectives were not counted. Similarly, habitat restoration might be required in some cases to achieve the water quality objectives at some sites, but it was not costed unless costing figures were provided by the RAP team.

Not all possible remediation options were examined, either. In general, the consultants examined options for which cost estimates were available. For example: "soft" approaches to pollution abatement, such as greater source-treatment of sewage, were not examined and costed. If several alternative remediation approaches were being considered to a problem, such as either "capping" contaminated sediments or dredging them, the consultants, in discussion with the RAP coordinators, selected one approach to present the costs and benefits.

the benefits of remediation

The consultants estimated two types of economic effects of achieving the four selected water quality objectives at the sites:

- economic value benefits accruing from people engaging in new or more enjoyable recreational activities and from simply knowing that the water is cleaner; and

- economic impacts arising from the expenditures made in implementing and maintaining the control measures, and from expenditures associated with the new or increased recreational activity which occurs.

The economic value benefits, known as "net willingness-to-pay", were of two types: "use value" and "non-use" (or "intrinsic") value. The use value represents the intrinsic values that accrue to residents simply from knowing that the water is cleaner and that they or their descendants could participate in new or enhanced recreational opportunities as a result.

Not all potential benefits were estimated. For example: the benefits which might accrue from other activities such as commercial fishing, recreation boating, hiking and so on were not estimated. The exclusion of these, and other, benefits was based solely on the need to focus the study. These other benefits could be important.

sources of information

This study was carried out using secondary data and information. That is, the consultants worked largely from existing reports and available information. The single most important sources were the work of the local RAP teams. These RAP reports identify the existing impairments of uses of the local water, their causes and possible remedial measures and an action plan to meet the specific objectives for water quality. The consultants accessed other Canadian and American sources to augment the information provided by the RAP teams.

CONCLUSIONS

The study succeeded in both providing order-of-magnitude estimates of the costs and benefits for the remediation process for the Areas of Concern, and in providing a framework that could be used by the RAP teams or the Ministry to prepare more detailed estimates of local costs and benefits.

The methods developed in this study provide a framework for organizing information and analyzing trade-offs. The study illustrates the uncertainties and information gaps that exist in this type of analysis. The work sets out a blueprint for carrying out more detailed studies as required for the individual RAP sites.

The annual economic value benefits (use and non-use) for all Ontario of achieving all water quality objectives at all 17 RAP sites are estimated to be $270 million. This represents the economic value which would arise in a typical year following implementation of the measures required to achieve all the water quality objectives. The large proportion of these benefits ($220 out of $270 million), are of the non-use, i.e., intrinsic type, and are therefore very sensitive to underlying assumptions regarding non-use benefit estimation. All dollar values are presented in 1989 Canadian dollars.

The annualized costs of achieving the four water quality objectives at all 17 sites are estimated to be $300 million. As noted in Exhibit 3, the urban run-off problem accounts for 53% of these expenditures; sewage treatment plants for a further 12%; and industries for another 28%. The costs to industries are under-estimated since there were some industries (e.g., pulp and paper) for which no reliable cost estimates were available.

The economic impact of these remedial expenditures is substantial. The capital costs associated with achieving all four water quality objectives are estimated to generate income for Ontario residents of $1.2 billion and to create approximately 27,400 person years of employment. The continuing operations and maintenance expenditures will generate annual income of about $165 million and create about 4,500 jobs per year. In addition, the expenditures associated with increased sportfishing and swimming will result in a further annual income to Ontario of about $40 million and some 1,200 jobs per year. Together, operation, maintenance and recreational expenditures will generate about $205 million in income and 5,700 jobs per year after achievement of all four water quality goals.

Exhibits 1 and 2 on the following pages present summaries of the benefits and costs of achieving all of the water quality objectives at all of the sites.

The distribution of these costs and benefits, i.e., the extent to which they will fall on particular sectors of society, is an important issue which is being addressed in other MOE studies.

Exhibit 1

SUMMARY OF ECONOMIC EFFECTS OF ACHIEVING WATER QUALITY OBJECTIVES

	ANNUAL ECONOMIC VALUE		EMPLOYMENT GENERATED WITHIN ONTARIO	
Goal	To RAP Site Residents	To all Ontario Residents	During Implementation[1]	Post Implementation[2]
	($1989millions)[3]		*(person-years)*[4]	*(jobs per year)*[4]
Aesthetically pleasing	$20	$50	10,000	900
Swimmable[5]	n/a	n/a	21,000	3,700
Edible fishery	$80	$180	18,000	3,900
Self-sustaining sportfishing	$90	$190	26,200	4,400
All objectives	$140	$270	27,400	5,700

1 Reflects total employment generated by implementation of control measures required to achieve each objective. This employment would be spread out over the period required for implementation of the control measures.

2 Reflects employment generated annually in connection with operating and maintaining control measures.

3 Rounded to the nearest ten million.

4 Rounded to the nearest hundred.

5 Due to the methods used in the literature for estimating non-use benefits, a separate estimate of the total economic value of achieving the swimmable objective is not possible. The use value portion of the economic value associated with achieving this objective is $30 million.

EXHIBIT 2

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

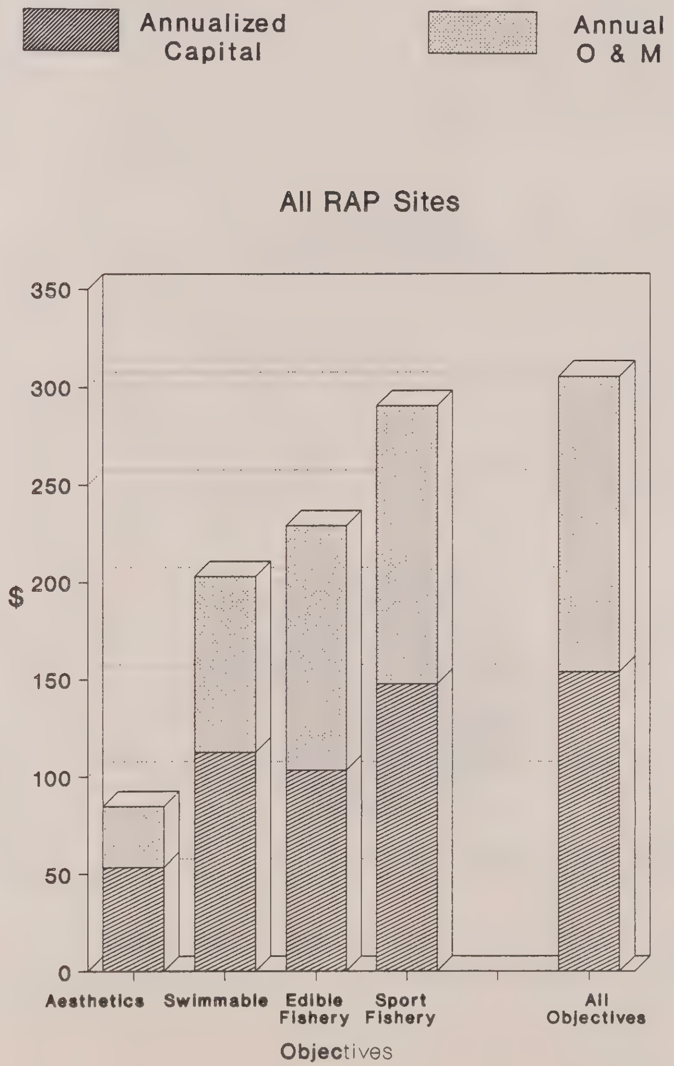
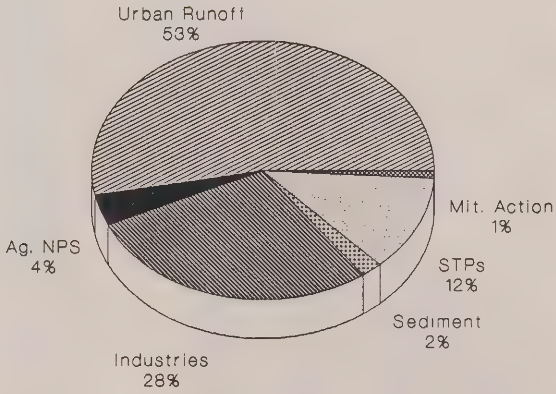


EXHIBIT 3

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

All RAP Sites



1.0 BACKGROUND, PURPOSE AND FORMAT OF THE REPORT

BACKGROUND

In 1909 Canada and the United States signed the Boundary Waters Treaty in which they agreed to manage and protect jointly shared Great Lakes water. The treaty established the International Joint Commission (IJC) to oversee related water-quality and water-quantity issues. This treaty was the first in a series signed by the two countries in an effort to restore and protect the water and natural resources of the region.

To strengthen this resolve, the two countries signed the Great Lakes Water Quality Agreement (GLWQA) in 1972 committing both sides to an aggressive cleanup campaign. The focus of this agreement was the conventional pollutants that have contaminated all the lakes to a greater or lesser extent. It specified controls on phosphorus, the source of much of Lake Erie's and some of the other lakes' degraded condition. The agreement has been updated twice, most recently in 1987; both of the later agreements emphasize the need to reduce toxic inputs. The region's premiers and governors also signed the Great Lakes Toxic Substances Control Agreement in 1986 endorsing a unified, preventive approach to restoring and protecting the lakes' water quality.

The IJC began to identify areas where pollution problems were particularly bad in the early 1970s. It created a list of "areas of concern", defined to be harbours, river mouths, and connecting channels where use for fishing, swimming, navigation, or drinking has been impaired by the presence of excess pollutants. As defined in the 1987 amendments, an "'area of concern' means a geographic area that fails to meet the General or Specific Objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life." (Annex 2, Section 1(a)) The Commission now lists 42 areas of concern; 17 of these are on the Canadian side of the lakes or are shared with the U.S..

The 1987 amendment by both countries to the GLWQA specified, among other things, the preparation of Remedial Action Plans (RAPs) for designated Areas of Concern.

The Canadian and U.S. federal governments, the relevant U.S. state governments, and the Province of Ontario have committed themselves to developing such Remedial Action Plans for each of 42 Areas of Concern which have been identified. In particular, remedial action plans are required for each of the 17 sites in Canada.

Generally speaking, a Remedial Action Plan is intended to address a number of environmental problems associated with water quality. Typically, in any Area of Concern, there is a number of known sources of these problems which must be remediated in order to show improvement in water quality.

In the end, a Remedial Action Plan incorporates an analysis of existing environmental conditions, existing and potential remedial measures, definitions of impaired uses and their causes, and an action plan to meet the specific objectives for water quality. Considered from an economic perspective, the implementation of the Remedial Action Plans typically involves the expenditure of significant resources to put the remedial measures in place, and can be expected to lead to the achievement of significant use and intrinsic (or non-use) benefits and economic value benefits in the form of increased employment and income.

The Ministry has undertaken socio-economic assessments of two Remedial Action Plans - Hamilton Harbour and the Bay of Quinte. These studies raised the issue that there is a need to have broad economic factors to support the preliminary evaluation of possible remedial measures, and to assist in the strategic management of the program. In other words, Ministry and the RAP teams can use estimates of economic costs and benefits when developing the Remedial Action Plans, rather than merely conducting a socio-economic assessment of a relatively finalized plan.

PURPOSE AND CAVEATS

The purpose of this study, undertaken for the Ontario Ministry of the Environment, was two-fold:

- to provide estimates of the orders of magnitudes of the benefits and costs of restoring the beneficial uses of the 17 Areas of Concern in the Great Lakes identified by the International Joint Commission (IJC). These 17 Areas of Concern are either on the Ontario side of the lakes or are shared with the U.S; and

- to develop a general framework for studying costs and benefits by describing the steps involved in estimating the costs and benefits for these remedial actions.

The estimates of costs and benefits were to be indicative only, signalling the likely orders of magnitude rather than precise estimates of costs and benefits. The results were intended to be used in the overall planning of the RAP program, and not for estimating the detailed costs and benefits for each of the RAP sites.

The study was intended to be preliminary in nature. It was the first attempt to quantify the costs and benefits of remedial actions which may be needed to restore the beneficial uses of all of these areas of concern. It establishes a framework for further, more detailed work which might be required at the individual RAP sites.

The study does not attempt to suggest the specific remedial actions which should be undertaken at the individual RAP sites, but it does provide indicative cost estimates of carrying out the remedial actions which have been suggested by the RAP teams or which would achieve the water quality objectives selected for consideration. Clearly, the selection of the appropriate remedial actions will be made by the appropriate authorities.

It will be seen in the body of the report that a set of four standard water quality objectives was selected as the basis for preparing the estimates of costs and benefits. The water quality objectives were:

- aesthetically pleasing.
- swimmable;
- able to support an edible fishery; and
- able to support a self-sustaining sportfishery.

These four water quality objectives may or may not be the specific use goals which the individual RAP teams are working from. The purpose of selecting this set of water quality objectives, as explained later in this report, was to provide a common basis for estimating costs and benefits across all of the 17 sites, without requiring a detailed analysis of each of the sites. These four objectives were believed to be representative of the water quality objectives being considered by the RAP teams and Public Advisory Committees.

FORMAT OF THE REPORT

This report consists of six sections.

This first section, *Background, Purpose and Format*, summarizes the background of the issue and the purpose of this study.

The second section, *Approach and Scope*, describes the overall approach and the major scoping decisions which were made to put reasonable bounds on the work to be done. These decisions must be appreciated if the results are to be understood properly.

Section 3, *Water Quality Objectives, Remedial Actions, and Technical Methods of Cost Estimation*, presents the set of standard water quality objectives that was selected for this study, the remedial actions that were considered for sites that were not currently meeting these water quality objectives and a summary of the technical approaches that were taken to estimating the costs of the site remediations. More detailed descriptions of the technical approaches are presented in the Appendices.

Section 4, *Costs of Remediation*, presents the costs of bringing each of the RAP sites up to the set of standard water quality objectives. The current situation at each site is described briefly, followed by the required remedial actions and their costs.

Section 5, *Estimation of Economic Benefits*, then summarizes the approach taken to estimating the economic benefits of remediation, and the results of the estimations.

The final section, *Conclusions*, summarizes the results of the study and presents the conclusions of the work.

2.0 OVERALL APPROACH AND SCOPE

This study was the first-ever attempt to estimate the orders of magnitude for the costs and benefits of all of the RAP clean-ups. A number of decisions were made on the scope of the work and the methods to be used. These decisions, and the overall approach taken are summarized below and must be understood if the results of the study are to be appreciated.

OVERALL APPROACH

The problem confronting the RAP teams is one of remediating an entire aquatic ecosystem. This includes the physical habitat, the biota and the water chemistry of the area. For the purposes of this study, a simplified approach was taken in that it was assumed that the problem was to determine the reductions in pollution loadings that were required to bring the local water up to the water quality objectives.

Under this simplified approach, the steps to follow in developing waterbody remedial plans and identifying their associated benefits is illustrated in Exhibit 2-1 on the following page.

The sequential steps of the process consist of the following:

- determining the water quality objectives for the sites and defining these objectives in terms of water quality criteria (the first box on the exhibit);

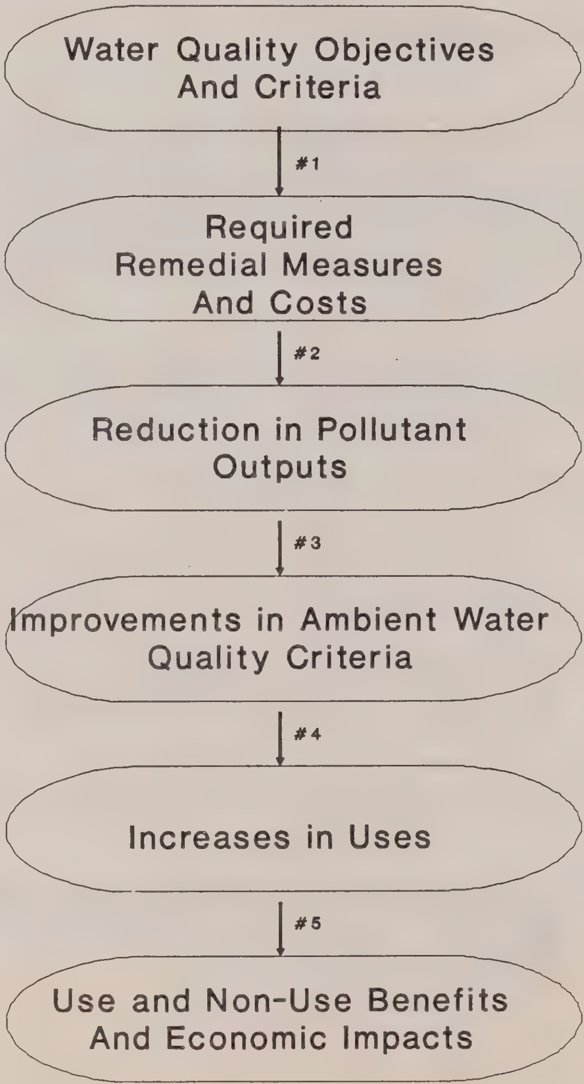
- identifying the types of remedial measures that have to be taken at the sites to achieve the water quality objectives (arrow #1 on the exhibit);

- linking the remedial measures to reductions in pollutant loadings (arrow #2 on the exhibit);

- linking reductions in pollutant loadings to improvements to the ambient water quality criteria that defined the water quality objective (arrow #3 on the exhibit);

Exhibit 2-1

Linking Remedial Measures to Improvements in Water Quality and Increased Benefits



- linking achievements of water quality objectives to increases in uses (arrow #4); and

- finally, expressing these increases in uses in monetary and non-monetary equivalents in benefits and estimating the economic impact of the remediation expenditures (arrow #5).

Unfortunately, in practice this approach is difficult to follow completely because of the complex biological and physical linkages which are present and which are understood only imperfectly. The problems encountered usually centre on trying to establish two of the links in this process, in particular the links represented by arrows #3 and #4 in the Exhibit.

Arrow #3 represents the link between reductions in pollutant loadings and the resultant improvements in ambient water quality criteria. In most cases, the physical, chemical and biological processes going on in a large water body are understood only imperfectly. Only in very special cases can scientists predict with accuracy what level of pollutant reduction must be achieved in order to achieve the required water quality indicator.

Several examples will illustrate this point.

Although it can be said, for example, that a 20% reduction in phosphorous should decrease algal growth and thus encourage the return of fish suitable for a sportfishery, it is not known how many fish will return and reproduce. Neither is it known if phosphorous reduction alone will encourage fish populations to return to historical levels. There might be other reasons why the fish have left the area. Or consider the case of toxics (for example, lead and mercury) which are accumulating in local fish and making them unsafe for eating. Suppose that there are two known local sites which are discharging mercury into the surrounding water. Will controlling mercury and lead discharges from these local sites remedy the situation with the local fish and lead to the establishment of a commercial fishery? The mercury in the fish could be coming from just these two local sources, from remote sources, or the mercury could be due to naturally occurring levels in the locality. In most cases, the scientific evidence isn't sufficient to answer these questions. This particular problem has plagued the RAP design and cost studies carried out in both Canada and the United States.

Similar problems arise with arrow #4, representing the linkage between the achievement of a water quality objective and the resultant increases in water

uses. Studies[1] have shown that there is a considerable degree of inconsistency between objective measures of water quality and public perceptions. While water may meet certain standards regarding pollution content, clarity, and so on, the response to these changes in terms of recreational activity will depend on sensory perceptions of water quality and general public opinion. The latter are unpredictable; thus, changes in recreational uses of the water have been assumed to respond to objective measures of water quality.

For the swimming objective, the implied relationship between the achievement of the water quality objective and the resultant recreational activity is evident. At the other extreme, it is very difficult to forecast changes in water uses which will arise as a result of aesthetic improvements. In the case of sportfishing, the increase in activity which is generated by achievement of the appropriate water quality objectives will be highly dependent on the effect which the control measures have on fish yield. There are a few studies (see references #24, 45 and 64 at Appendix I) which link changes in specific pollutants to changes in fish yields; however, there are no models which estimate linkages between pollution in general and fish yields. In the absence of such information, estimates of new fishing activity have been made on the basis of current regional sportfishing patterns, and on the assumption that increases in fish yield are sufficient to meet local demand.

The approach used in this study has followed the process of Exhibit 2-1, but several important assumptions have had to be made to deal with the problems that arise in trying to establish these two particular links. These assumptions are described below and in the sections on the costs and benefits at the individual sites.

SCOPING DECISIONS

estimating overall costs and benefits

The order-of-magnitude estimates of overall program costs and benefits were derived on a site-specific basis. That is, costs and benefits were calculated for each of the 17 sites and then summed to present the overall costs and benefits.

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[1]Binkley, Clark F., and W. Michael Haneman, *The Recreation Benefits of Water Quality Improvement, Analysis of Day Trips in an Urban Setting*, EPA, Contract 68-0-2282, June 1978; Caulkins, P., R.C. Bishop, and N.W. Bowes, Sr., *The Travel Cost Model for Lake Recreation - A Comparison of Two Methods for Incorporating Site Quality and Substitution Effects*, American Agricultural Economics Association, 1986.

standard water quality objectives

A standard set of water quality objectives was selected to be used at all sites as opposed to carrying out a detailed analysis of each of the sites. The water quality objectives used were water which was:

- aesthetically pleasing.
- swimmable;
- able to support an edible fishery; and
- able to support a self-sustaining sportfishery.

Technical criteria were then set for determining whether a water body was in accord with these objectives. These criteria are presented in the next section of the report.

These water quality objectives were believed to be representative of the objectives being examined by the individual RAP teams, but the set is not intended to be exhaustive. Other water quality objectives such as the development of commercial fishing are being examined by some of the RAP teams.

This selection of a standard set of water quality objectives led to one particularly important issue. At some of the sites, the technical criteria for the selected water quality objectives (as noted in Exhibit 3.1) were not met. Thus, remedial measures were costed, yet some of the local users of the water body did not agree that the water quality objectives were in fact impaired. For example: at some sites, the sportfishery was impaired according to the technical criteria used for this study. Yet some users fish there regularly and doubted that there would be any significant increase in fishing if the remedial actions were undertaken. The fact that remedial measures have been costed in these cases does not imply that the study has pre-empted decisions about water impairments or remedial measures at the RAP sites. The purpose of this approach was to ensure consistency across all 17 sites. One direct implication of this approach is that the costs are probably over-estimated in this situation. In practice, the appropriate authorities would probably not take remedial actions which were not deemed beneficial by the ultimate users of the water body.

sources of pollution

The study considered six sources of pollution as potentially contributing to the water quality impairment at the RAP sites:

- sewage treatment plants;

- urban runoff;
- agricultural runoff;
- toxic wastes of industries;
- contaminated sediment; and
- leakage from existing toxic waste sites.

In its own work, the IJC has identified a seventh source of pollution in the Great Lakes, namely airborne deposition. That source has not been counted in this analysis, primarily because so little is known about it.

remediation actions and costs

The costs of remediating a particular site were calculated by first determining the sources of pollution present at that site and then costing the appropriate remedial actions. Details of the remedial actions considered for each of these sources of pollution, and the costing approach used for each such remedial action, are presented in the next section of this report and in the appendices to the report.

Not all remediation costs could be counted, given the time and budget limitations of the study. The consultants estimated the costs that were judged to account for the majority of the likely costs of remediation. For example: costs of on-going monitoring for compliance and for testing of the water quality objectives were not counted. Similarly, habit restoration might be required in some cases to achieve the water quality objectives at some sites, but it was not costed.

Not all possible remediation options were examined, either. In general, the consultants examined options for which cost estimates were available. For example: "soft" approaches to pollution abatement, such as water demand management or greater source-treatment of sewage, were not examined and costed. If several remediation approaches were being considered, such as either "capping" contaminated sediments or dredging them, the consultants, in discussion with the RAP coordinators, selected one approach to present the costs and benefits.

the benefits of remediation

The consultants estimated two types of economic benefits of achieving the four selected water quality objectives at the sites:

- economic value benefits accruing from people engaging in new or more enjoyable recreational activities and from simply knowing that the water is cleaner; and

- economic impacts arising from the expenditures made in implementing and maintaining the control measures, and from expenditures associated with the new or increased recreational activity which occurs.

The economic value benefits, known as "willingness-to-pay", were of two types: "use value" and "non-use" (or "intrinsic") value. The use value represented the increase in welfare to people who actually use the water, for sportfishing or swimming. The intrinsic values accrue to residents simply from knowing that the water is cleaner and that they could participate in new or enhanced recreational opportunities as a result.

Not all potential benefits were estimated. It will be seen that the study focused on recreational uses of the water bodies and the associated benefits. For example: neither the human health benefits of cleaner water nor the benefits which might accrue from commercial fishing and boating were estimated. The exclusion of these, and other, benefits was based solely on the need to focus the study. These other benefits could be important.

sources of information

This study was carried out using secondary data and information. That is, the consultants worked largely from existing reports and available information. The single most important sources were the work of the local RAP groups. These RAP reports identify the existing impairments of uses of the local water, their causes and possible remedial measures and an action plan to meet the specific objectives for water quality. The consultants accessed other Canadian and American sources to augment the information provided by the RAP teams.

a static picture

The work of the RAP teams is progressing, and they are learning continuously about the problems and solutions to the local problems. This report presents a "snapshot", that is a static picture of an evolving situation. The indicative costs and benefits reported reflect what is going on currently at the sites. No predictions have been made about population growth, industrial expansion or contraction, expected changes in factors such as rainfall or water levels, and other factors that will influence the importance of the various sources of pollution and of the remedial actions and the resultant benefits.

3.0 THE WATER QUALITY OBJECTIVES, REMEDIAL ACTIONS AND TECHNICAL METHODS OF COST ESTIMATION

THE WATER QUALITY OBJECTIVES

One of the purposes of this study was to provide an indicative estimate of the costs and benefits of remediating the 17 areas of concern. The first step in the study, then, was to select a set of representative water quality objectives for the 17 sites, and their associated ambient water quality criteria.

In consultation with officials of the Ministry of the Environment and representatives of the RAP teams, a set of four water quality objectives was settled upon. These water quality objectives, with their associated ambient water quality criteria, are presented in Exhibit 3-1 on the following page.

The comment made in the *Background* section should be repeated here. The use of these four representative water quality objectives is not intended to preclude decisions by the local RAP teams, the Public Advisory Committees or anyone else, as to the desirable water quality or water uses for the areas of concern. The RAP teams and the Public Advisory Committees are considering a variety of water quality objectives based on their local circumstances. This set of four water quality objectives is intended merely to be representative of the types of water quality improvements that are being examined by the RAP teams. The objectives are useful in preparing this assessment of the likely costs and benefits of remediating the 17 sites, in total.

These water quality objectives are neither hierarchial nor are they mutually exclusive. They are just four different set of quality objectives which could be set for the waterbodies, with each objective having its own associated ambient water criteria and required remediation measures.

REMEDIAL ACTIONS

Once the water quality objectives and their associated ambient criteria had been set, it was then necessary to determine the types of remedial actions that could be required to bring the local water up to the ambient criteria of each of the water quality objectives.

EXHIBIT 3.1

REMEDIAL ACTIONS NEEDED TO ACHIEVE WATER QUALITY CRITERIA

WATER QUALITY OBJECTIVES AND CRITERIA	REMEDIAL ACTIONS
AESTHETICS	
lack of debris, oil, scum, and substance which would produce an objectionable deposit, colour, odour, or taste; nuisance algae or aquatic plants; and water clarity (secchi disk reading of 1.2 m)	• primary sewage treatment • urban runoff control and treatment program • rural erosion control if appropriate
SWIMMABLE	
where user is immersed in water: 100 fecal coliforms per 100 ml; 1000 total coliforms per 100 ml; lack of debris, oil, scum, or any substance which would produce objectionable deposit, colour, odour, taste, or turbidity; water clarity (secchi disk reading of 1.2 m); and pH of 6.5 - 8.5	• secondary sewage treatment defined as (BOD)5 of 24 mg/l or less with additional phosphorus reduction to an average effluent concentration of 1mg/l or less • urban runoff control and treatment program • rural erosion control if appropriate
EDIBLE FISHERY	
the absence of levels of toxics in fish tissues at concentrations deemed harmful by public health guidelines	• BAT standards for industries • urban runoff control and treatment program • sediment removal and disposal if these are shown to cause toxic contamination in fish • hazardous waste removal and disposal

SPORT FISHERY

conditions that allow the return and natural reproduction of sport fish at a level that attracts sport fishing activity (acceptable warm or cold water fish) as defined by site RAP coordinator or the MOE

- BAT standards for industries
- urban runoff control and treatment program
- sediment removal and disposal if these are shown to cause toxic contamination in fish
- hazardous waste removal and disposal
- secondary sewage treatment defined as (BOD)5 of 24 mg/l or less with additional phosphorus reduction to an average effluent concentration of 1 mg/l or less
- agricultural NPS best management practices

Discussions with the RAP coordinators and officials of the Ministry of the Environment, literature reviews and the experience of the project team lead to the identification of six possible sources of pollution that could require remedial actions. These six sources of contamination were:

1. *sewage treatment plants* affecting the waterbody;

2. *urban runoff* into the affected area;

3. *agricultural non-point source runoff* into the area;

4. *industrial point sources* of pollutants;

5. *contaminated sediments* already deposited into the areas of concern; and

6. *toxic waste sites* that were leaking into the areas of concern.

These six potential sources of contamination are in accord with the results of the IJC's work. The IJC has a seventh source of contamination of the areas of concern, namely airborne deposition, but that source is not dealt with in this study primarily because so little is known about it.

Although the team was prepared to deal with toxic waste sites, it turned out that none of the RAP teams had sufficient information about the hazardous sites to allow costs to be estimated.

Each of the four water quality objectives could be expected to require different approaches to these sources of pollution. For example: achieving the objective of *swimmable water* could be expected to require different remedial actions than achieving the objective of water which supported *edible fish*.

The study considered a total of seven types of remedial actions that might be required at a site to achieve one or all of the water quality objectives:

- primary treatment of sewage effluent;

- secondary treatment of sewage effluent with additional phosphorous removal;

- urban non-point runoff control and treatment program;

- rural non-point source pollution and erosion control;

- best available technology standards (BAT) for industries' effluents;

- sediment removal and disposal; and

- hazardous waste removal and disposal.

Exhibit 3-1 also presents, for each water quality objective, the remedial actions which might be required to bring the ambient water criteria up to meet the water quality objective.

An example of how to interpret this table is as follows:

> "to achieve the objective of *edible fishery* requires
> the following remedial actions:
>
> - the installation of BAT standards for the effluents of industries;
>
> - the control and treatment of urban run-off;
>
> - the removal and disposal of contaminated sediments if they are contributing to fish toxicity; and
>
> - the removal of hazardous waste sites leaking into the water body."

Each RAP site might require a different combination of these remedial actions to deal with its specific problems.

As noted earlier, not all possible remediation options were examined. In general, these seven remedial actions are ones for which cost estimation approaches exist and they are believed to account for the large proportion of the likely costs.

For example: "soft" approaches to pollution abatement, such as water demand management or greater source-treatment of sewage,.were not examined and costed. If several remediation approaches were being considered to deal with the same problem, such as either "capping" contaminated sediments or dredging them, the consultants, in discussion with the RAP coordinators, selected one approach to present the costs and benefits.

TECHNICAL METHODS OF COST ESTIMATION

The first approach attempted in estimating the costs of remedial actions was to determine if the RAP team had prepared such estimates for the remedial actions being considered. If so, these estimates were generally used.

If this cost information did not exist, then other methods were used. Exhibit 3-2 on the following page summarizes the costing methods used for each of the sources of pollutants and the appropriate remedial actions. More detailed information on the approaches used is contained in the appendices.

Several technical points are important to understanding the costs presented.

- The capital costs for remediating a site have been presented both in total, and as an equivalent uniform annual cost (UAC) in Appendix A. In making these calculations, the follow assumptions were used:

    - the life expectancy for industrial capital expenditures will be 10 years and 20 years for public sector expenditures; and

    - a discount rate of 10% was used.

- The costs presented in the graphics of Section 4 for each site are annualized capital costs and annual operating and maintenance costs.

- These costs are based on average experiences. Individual RAP sites could expect their actual costs to vary significantly.

- The U.S. BAT-EA costs are imperfect tools for estimating Canadian industrial expenditures on effluent controls. The U.S. costs do not reflect the differences between Canadian and U.S. industrial structures, and in some cases the BAT-EA specifications and costs are outdated.

Finally, it must be repeated that the costs of remediation are not additive across water quality objectives. For example: if the cost of achieving the *aesthetic* objective is $10, and the cost of achieving the *swimmable* objective is $20, it is not necessarily true to conclude that the cost of achieving water which is both aesthetically pleasing and swimmable would be $30 ($10 + $20). Different water quality objectives sometimes require some of the same remedial actions.

EXHIBIT 3.2
METHODOLOGY FOR COSTING REMEDIAL ACTIONS

SOURCE OF POLLUTANTS	REMEDIAL ACTIONS AND COSTING METHODOLOGY
Sewage Treatment Plants	Primary to Secondary with Nutrient Removal • Cost equations developed by the U.S. EPA were used to estimate capital and operating and maintenance costs. These equations were formulated as a function of throughput in dollars per 1000 m3 or millions of gallons per day treated. Secondary to Additional Nutrient Removal • Cost effectiveness tables developed by the EPA for advanced phosphorus removal were used to estimate capital and operating and maintenance costs.
Industrial Point Sources	• Costs of implementing U.S. BAT regulations were taken as proxies for the industry costs of implementing control of toxic pollutants for the following sectors: steel; metal moulding and casting; metal finishing; organic chemicals; and inorganic chemicals.
Urban Runoff	• A stormwater utility approach which relies on dedicated user fees to fund stormwater and urban runoff control and treatment was used. A per capita charge based on a survey carried out of 25 stormwater utilities in 1986 was estimated and used for capital and operating and maintenance costs for the RAP sites.
Agricultural Non Point Sources	• The results of a linear programming simulation model developed for a case study of best management practices in Honey Creek, Ohio was used to estimate costs. Cost-effectiveness figures were estimated for head of cattle and on a per hectare basis if feedlot information was unavailable.
Contaminated Sediment	• Dredging, transport, disposal and treatment of sediment were estimated using figures developed by the U.S. Army Corps of Engineers. The costs of capping sediments were also based on estimates provided by the U.S. Army Corps of Engineers.
Toxic Waste Sites	• Costs of waste disposal site cleanup vary widely. Costs for removing the waste site material only were estimated, using estimates developed by the U.S. Congress' Office of Technology Assessment.

IMPORTANT ASSUMPTIONS

Four important assumptions were made to facilitate the linking of pollutant reduction with the achievement of the water quality objectives.

- Whenever possible, the best professional judgment of the RAP or other experts working at the sites was used to judge the reduction in pollutant loading that was required to achieve the water quality objectives.

- When it was not possible to make such a judgment, it was assumed that the source of the pollutant would be brought into accord with the BAT-EA technical standards of the U.S. Environment Protection Agency. As noted above, these standards have no force in Canada, but they represent a relatively complete set of pollution standards for a range of polluting facilities and are one of the approaches being considered by the Ontario Government in developing its own standards under MISA.

- It was assumed that the local sources of contaminants were responsible for the contamination of local fish. For example: in the case of the mercury and lead-contaminated fish, it was assumed that eliminating lead and mercury discharges from the local discharge sources would result in the elimination of these toxics from the fish.

- Finally, in the case of RAP sites that shared remediation responsibility with the United States, it was assumed that the U.S. RAP teams would also carry out the appropriate remedial actions to ensure that the water body was brought up to the water quality objectives.

4.0 COSTS OF REMEDIATION

The costs of remediating the 17 sites, i.e., of bringing them up to the four selected water quality objectives, depend on:

- the sources of the pollution that are causing the local use impairment;
- the extent to which the current ambient water quality measurements fall short of the criteria required by the water quality objectives; and
- the current pollution abatement and control measures in force locally.

The next section summarizes the current knowledge about the sources of pollution, extent of the problem and impairments being experienced by each of the 17 sites. This is followed by indications of the likely remediation costs of achieving the four water quality objectives at the 17 RAP sites.

Information on each site was obtained from the RAP co-ordinators, Stage 1 documents, and other MOE documents which described the sites.

Where information was not specified by the RAP teams about which criteria were not met at their sites, the consultant team has made judgments about the water quality objectives which are impaired based on the description of the water quality at the area of concern.

COSTING METHODOLOGY

Costs were estimated for achieving the water quality objectives which were impaired at each site.

A detailed description of the methodology used to arrive at these costs is presented in Appendix B. A brief summary of the steps is as follows:

1. The remedial actions required to achieve the four water quality objectives were identified for each of the 17 sites, in conjunction with the RAP representatives. The RAP coordinators were asked

to provide information on their cost estimates for the remedial actions. Where this cost information was available, it was used.

2. In cases where cost information was not available from the RAP teams, the study team used a variety of technical sources, both Canadian and U.S., to estimate the remedial costs. Details of the approach used for each of the six types of pollutant source are at Appendix B.

3. There were some cases in which no cost estimates could be obtained, either from the RAP teams or from the technical literature and experts. The removal of dioxins from pulp and paper effluents is the most significant example of this situation. When appropriate, this fact is noted on the results reported for the RAP sites. A complete list of pollution sources which were not costed at each site appears as Table 4.1 on the following page.

Unless specified by the RAP coordinators, it was assumed that the remedial actions specified in Exhibit 3-1 were needed in order to bring the sites up to the objective specified. The costs presented summarize the indicative costs of remediating the sites to the four water quality objectives. Details of costs for each site appear as Appendix A.

Costs estimated for the connecting channels (St. Marys, St. Clair, and Detroit Rivers) are for the remedial actions needed by Ontario only. Remediation plans and actions for the U.S. waters will be the responsibility of the U.S. participants in the RAP process.

INTERPRETING THE COSTING DATA

Costs shown in the bar charts are broken down into annualized capital and annual operating costs. That is, the costs reflect what is required, each year, for twenty years, to cover the costs of remediation.

The pie charts show how the costs which have been estimated for remediating the sites are broken down by source of pollutant.

One of the most important points to remember when interpreting the costs are that in many cases, the costs are low because data were not available to cost the remedial actions for certain industries and discharges. As well, some of the RAP sites are still in the primary stages of research and could not provide

TABLE 4.1

SOURCES AT EACH SITE NOT COSTED DUE TO LACK OF INFORMATION

Site	Source	Reason
1. Bay of Quinte	Corby Distilleries	BAT costs not available
2. Detroit River	General Chemical (organic chemical producer)	BAT costs not available
	sediment	no cost estimates available
	hazardous waste sites	no cost estimates available
	agricultural land	no cost estimates available
3. Jackfish Bay	Kimberly-Clark (pulp and paper mill)	BAT costs not available
4. Metro Toronto	urban runoff (Mimico Creek)	no cost estimates available
5. Niagara River	agricultural non-point sources	no estimates available for farmland or number of cattle
	tonnes of hazardous waste	not yet estimated
	cubic yards of sediment to be disposed of	not yet estimated
6. Nipigon Bay	Domtar (pulp and paper mill)	BAT costs not available
7. Peninsula Harbour	sediment contamination	estimates of areas to be dredged not available
8. St. Clair River	hazardous waste sites	no cost estimates available
	sediment	no cost estimates available
	CIL	BAT costs not available
9. St. Lawrence River	sediment	no estimates of areas to be dredged
	Domtar Fine Paper	BAT costs not available
10. St. Marys River	hazardous waste sites	no cost estimates available
	sediment	no cost estimates available
	St. Marys Paper	BAT costs not available
11. Thunder Bay	Canadian Pacific Forest Products	BAT costs not available
	Northern Wood Preservers	BAT costs not available
	Abitibi-Price, Provincial Paper mill, Thunder Bay and Fort William mills	BAT costs not available

the RAP sites are still in the primary stages of research and could not provide

information on areas of sediment to be dredged, hazardous waste to be removed etc.

Finally, and most importantly, the definitions of impairment of water quality objectives were based on the water quality criteria presented as Exhibit 3-1 in Chapter 3 unless the RAP co-ordinators described precisely which uses, in their opinion were impaired. In some cases the water quality objectives will coincide with the goals that the Public Advisory Committees have elaborated and in some cases they will not.

All costs in the bar charts and appendices are reported in 1989 Canadian Dollars. In some cases, cost ranges were available for remedial actions. In these cases, the highest costs were the ones used in the charts following each site.

BAY OF QUINTE

The major problem with the Bay of Quinte is eutrophication due to phosphorus loadings from the local Sewage Treatment Plants (STPs), Water Treatment Plants (WTPs), Combined Sewer Outflows (CSOs), rural non-point sources, and sediment feedback. The Bay also has high levels of algae, heavy metals and toxics in the sediments, as well as bacterial contamination. The high bacteria level and algae impair swimming and also make the water aesthetically unpleasing. The Bay's edible fishery is impaired because mercury, PCBs, and mirex, can be found in the fish. The Bay's sportfish are mainly walleye, with some yellow perch, pike and bass.

Loadings of phosphorus in the Bay come from two upstream sewage treatment plants, from agricultural areas located upstream, and from sediment which lays at the bottom of the water body.

The Bay of Quinte has bacterial and toxics contamination due to urban stormwater outflows. The RAP team has suggested that the infrastructure in the surrounding area must be examined to determine the cause of the outflows by-passing the sewage treatment systems in the urban areas.

Six sewage treatment plants discharge directly into the Bay of Quinte. There are also a number of industries on the Bay, those being Trent Valley Paperboard Mills, Domtar Packaging, Corby Distilleries, and Strathcona Paper.

Ecosystem models for the Bay of Quinte have been developed which link the reduction in phosphorus to increases in macrophytes (plant life). However, the linkage has not been made between the increasing macrophyte acreage and the increase in the number of fish (which feed on the phytoplankton which is sheltered by the macrophytes). The model is useful for determining the effect of various remedial options on phosphorus reductions in the Bay.

Various remedial options have been suggested by the RAP team for phosphorus removal by STPs, alum treatments, and lake flushing, and through non-point source agricultural programs. Costs for stormwater overflow treatment, sewage infrastructure rehabilitation, and industrial phosphorus reduction are not available. Work is currently in progress which is examining the level of toxics in the Bay and whether or not they have any effect on the ecosystem.

Toxics in the fish in the Bay are thought to come from local sources with some possible importing of contaminants from Lake Ontario. Since there is

no source of Mirex in the Bay of Quinte, Lake Ontario is being labelled as the source of this contaminant.

Current use data for the Bay of Quinte are available in a draft socio-economic study prepared for the Ministry.

Cost Estimates

Aesthetics, swimming, and an edible fishery were the water quality objectives costed for the Bay of Quinte. The majority of costs for the remedial actions in the Bay of Quinte were derived by the RAP team. The costs of reducing urban runoff were the only costs formulated by the consultants. BAT[2] costs estimated by the RAP team for toxics removal.

Total annual capital costs for achieving aesthetics, swimming, and an edible fishery in the Bay are estimated to be between \$3.5 and \$4.9 million. Annual operating and maintenance costs are estimated to be between \$6 and \$8 million. Operating and maintenance costs are high relative to capital costs due to the annual costs associated with implementing best management practices to control agricultural non-point sources of pollution.

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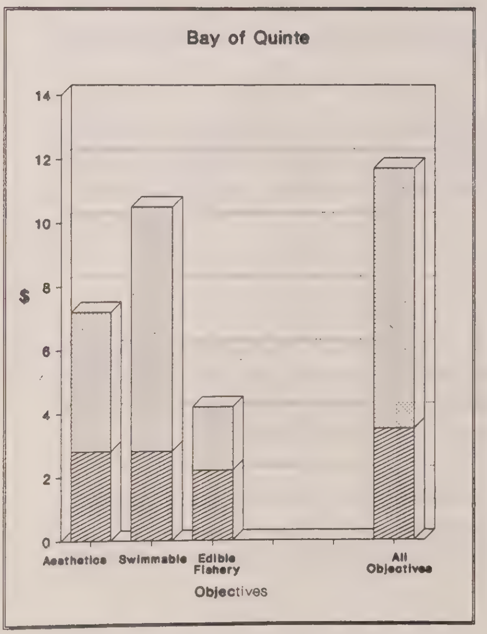
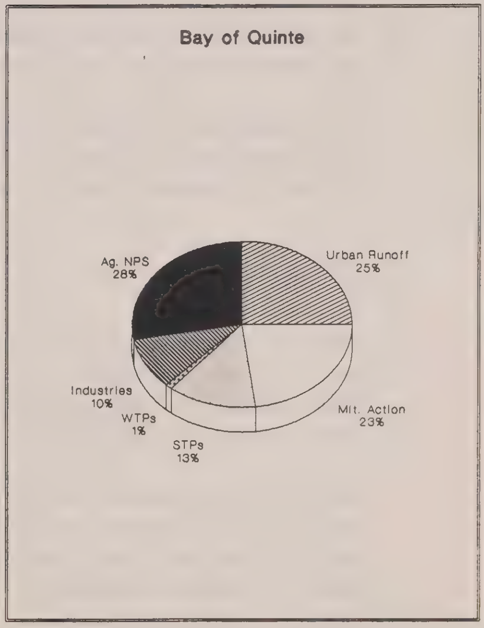
[2]Best Available Technology-Economically Achievable costs obtained from U.S. EPA studies. For a more detailed discussion of these costs and how they were used, see Appendix B.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital   Annual O & M

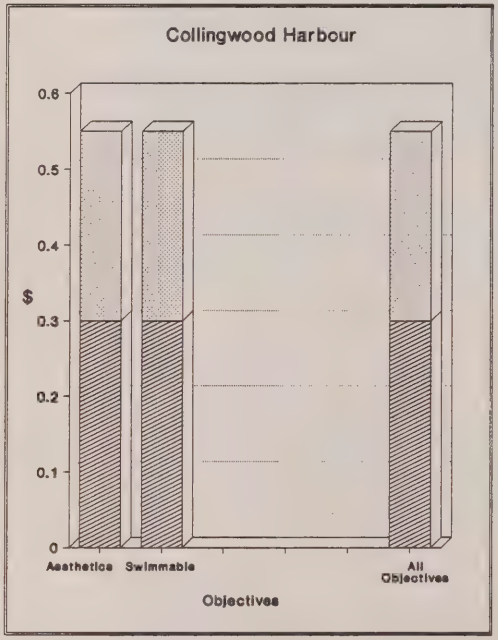


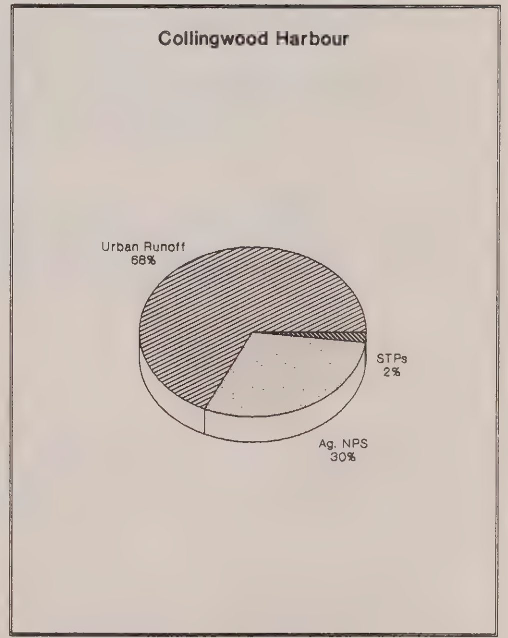


Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital   Annual O & M





DETROIT RIVER

The Detroit River is the furthest downstream connecting channel, connecting Lake Erie with Lake St. Clair and Lake Huron. The Detroit River watershed is home to a population greater than 5 million (both in Canada and the United States) and is one of the world's most heavily industrialized areas. This industry includes a vast automotive complex including fabrication and assembly as well as many metal and plastic-based support industries. Numerous other types of manufacturing activities also occur in this area.

Contamination problems in the Detroit River include:

- sediments contaminated with PCBs, oil and grease, mercury, and other metals;

- water quality violations for phenols, iron, and fecal coliform; and

- an impaired fishery (particularly by PCBs), waterfowl, and benthic community.

Swimming in the Detroit River is affected by the excess fecal coliform levels from the three STPs in the area. There are restricted consumption guidelines for mercury and PCBs for larger fish in the area which impair the areas edible fishery. Toxics in the fish are thought to come from a number of diffuse sources in the water basin. There is a sportfishery which exists in the Detroit River but which has a poor habitat for the fish because of toxics in the sediment and because of the dredging which occurs frequently in the Detroit River for shipping purposes. Aesthetics are also impaired in the river.

The three STPs along the Ontario side of the river discharge conventional pollutants, oil and grease, and heavy metals. Ford Motor Company, General Chemical, and Wickes Manufacturing all discharge heavy metals into the Detroit River.

Cost Estimates

Costs for all four water quality objectives were estimated by the consultants. Some remedial actions, such as; dredging of sediments, remediating hazardous waste sites, toxics removal from the effluent at General Chemical, and agricultural non-point source controls, were not costed due to a lack of information. This would indicate that the cost estimates for remediating the River underestimate the costs of achieving all four water quality objectives.

For the actions that were costed, STPs were responsible for the majority of the costs. Two of the three STPs which discharge directly into the river only have primary sewage treatment, and, in order to have swimmable water and a sportfishery according to remedial actions described in Exhibit 3-1, secondary treatment must be in place. Urban runoff was responsible for just over forty percent of the costs.

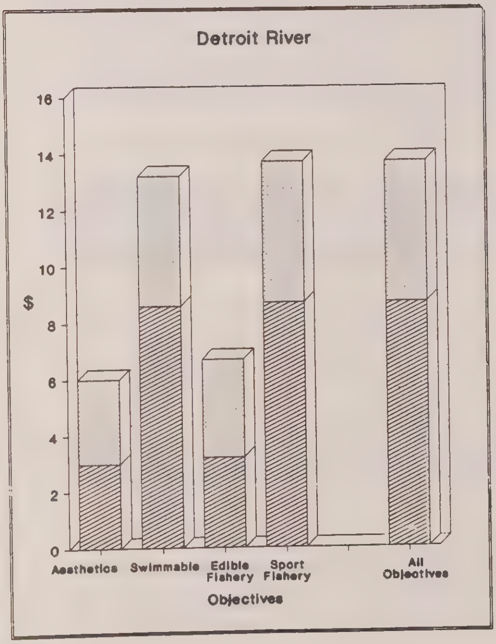
Annual capital costs of achieving the four water quality objectives in the Detroit River are estimated to be $8.7 million. Annual operating and maintenance costs for the river are $5 million. Water quality objectives will likely only be attainable with control of U.S. sources.

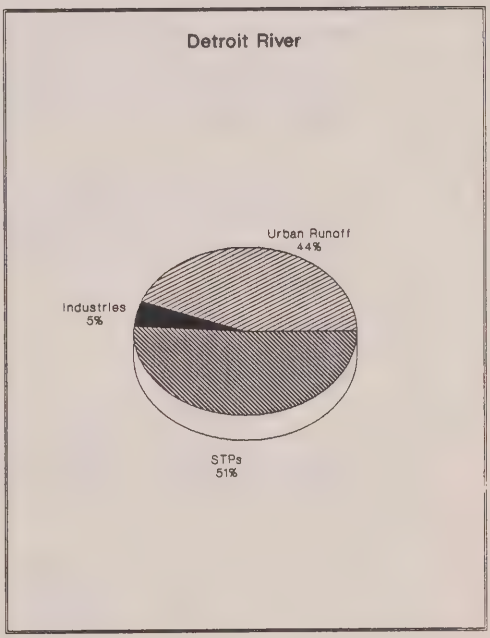
Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital

Annual O & M





HAMILTON HARBOUR

Hamilton Harbour receives runoff and waste effluent from a 494 square kilometre watershed. The watershed is rural in the upper reaches, urbanized in the eastern part around the Harbour, and supports the largest iron and steel industrial complex in Canada.

Swimming in the Harbour is impaired due to bacteria from CSOs and eutrophication due to STPs, CSOs, and agricultural non-point sources. Larger fish in the Harbour are restricted for consumption due to mercury, PCBs, and Mirex being found in the fish. This impairs the Harbour's edible fishery. There is no source of mirex in Hamilton Harbour. The mercury and the PCBs are thought to be from sediment release, urban runoff, and from industries.

The sportfishery in Hamilton Harbour is further impaired because of poor habitat partly due to eutrophication and because there is currently an excess of carp (a predator fish) in the Harbour. Aesthetics in the Harbour are impaired due to poor water quality from eutrophication and from the turbidity caused by the large number of carp.

Two STPs, Stelco and Dofasco, urban runoff from Hamilton and Burlington, and agricultural non-point sources of pollution are all responsible for discharging both conventional pollutants and heavy metals directly into the Harbour.

Cost Estimates

Estimates of achieving all four water quality objectives were prepared for Hamilton Harbour. The RAP team provided all costing information except BAT costs for Stelco and Dofasco.

One third of the costs for remediation of the Harbour appear to fall with Stelco and Dofasco. One-third of the costs for these industries are for recycling blast furnace cleaning water, while the remaining two thirds of the costs are BAT costs.

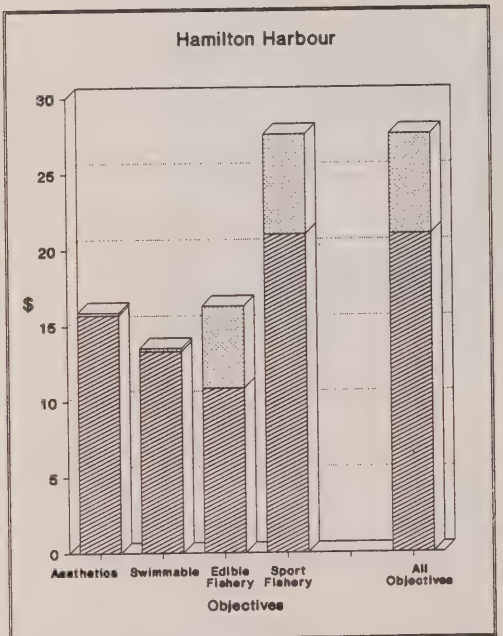
Urban runoff and STPs also have large cost burdens associated with them. One of the major costs associated with urban runoff for the Harbour are retention basins for the storm water in the urban areas. Costs for remediating sediment may be low as current costs cover the immediate hot spots in the harbour. Total costs for contaminated sediment remediation are still uncertain and could be higher than currently estimated.

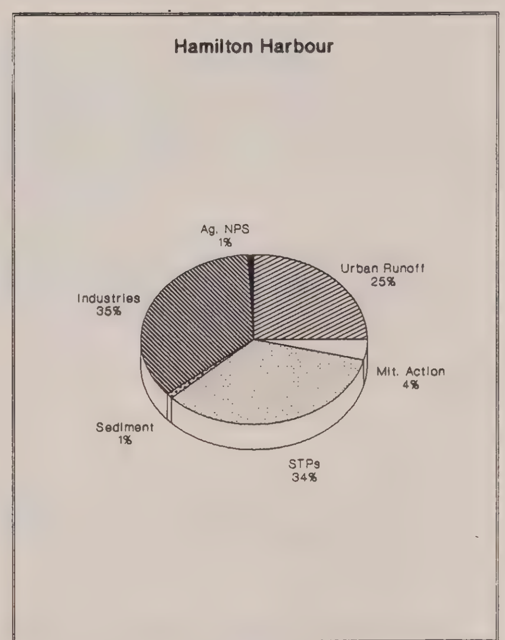
Annual capital costs of remediating the waterbody to achieve all four water quality objectives have been estimated to be approximately $21 million, with annual operating and maintenance costs being an additional $6.6 million per year.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital — Annual O & M





JACKFISH BAY

Jackfish Bay is located on the north shore of Lake Superior, approximately 250 km northeast of Thunder Bay. The bay contains two inner arms, Moberly Bay on the west and Tunnel Bay on the east.

Moberly Bay, receives the drainage from the Blackbird Creek system, which carries the wastewater discharges from the Kimberly-Clark of Canada pulp and paper operation. The water in Jackfish Bay is malodorous, discoloured and has high bacteria levels. Sediments are contaminated with toxic compounds, and there are some areas of the Bay which are not capable of supporting aquatic life.

With the exception of large lake trout, there are no current consumption guidelines. Toxics in the fish impair the areas edible fishery. The habitat of the fish caught for sportfishing has been impaired due to degraded water quality. There is reduced water clarity and general deterioration of aesthetic quality of Blackbird Creek and Jackfish Bay.

There are no STPs or other industries which discharge directly into Jackfish Bay.

Cost Estimates

Urban runoff was the only action costed in Jackfish Bay by the consultants. Since there are no STPs or agricultural runoff which discharge into the Bay, the costs of achieving swimmable and aesthetic water quality objectives is equal to the cost of controlling urban runoff. The RAP team is still undecided whether contaminated sediments in the Bay need to be removed and costs were not available to estimate removal of toxics from the Kimberly Clark effluent, therefore urban runoff was again the only option costed for Jackfish Bay.

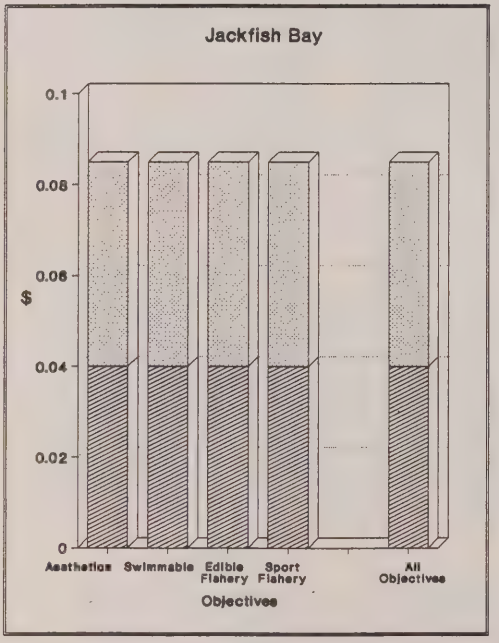
Annual capital costs of achieving all water quality objectives in the Bay are estimated to be $41,000, with annual operating and maintenance costs being an additional $41,000. These underestimate the cost of remediating the edible and sportfishery due to the lack of costing data available on Kimberly Clark and possible costs for remediating sediment not being included.

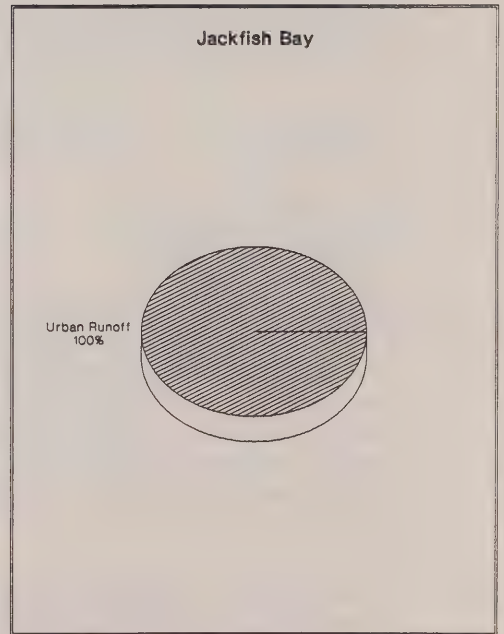
Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital

Annual O & M





METROPOLITAN TORONTO

The Metro Toronto waterfront is affected by bacteria, nutrient, heavy metal and organic chemical contamination primarily as a result of inputs from sewage treatment plants, combined sewers, and storm sewers. Agricultural non-point sources play a smaller role in polluting the area. Swimming is impaired at the waterfront during periods after high rainfall due to the increased bacteria from the CSOs.

There are over 80 storm sewer outflows which discharge urban runoff directly to Lake Ontario or Toronto Harbour. Over 2100 storm sewers discharge directly to the six area tributaries. The six tributaries are Etobicoke, Mimico, and Highland Creeks, and the Humber, Don, and Rouge Rivers.

There are also over 60 combined sewer overflows which discharge to the Humber and Don Rivers as well as four sewage treatment plants. The sediment in the Toronto Harbour appears to be a significant source of PCBs, copper, zinc, mercury, and iron to the aquatic life.

Loadings for discharges into the Toronto Waterfront and its tributaries are known and available. Although precise knowledge regarding the reduction in pollutant loadings to improvements in water quality indicators is not known, scientists suggest that a reduction in effluent from storm sewers and combined sewer overflows (CSOs) would decrease the amount of bacteria at the Toronto waterfront and increase the number of days beaches would remain open during the swimming season. Costs are available for both the elimination of CSOs and decreasing the storm sewer runoff. An estimate of the cost of managing and treating stormwater runoff has also been made.

Larger fish caught off the Toronto Waterfront have been found to have concentrations of PCBs, mirex, and mercury at levels higher than health standards and are not recommended to be eaten. These toxics impair the area's edible and sport fisheries. Point source pollutants from Toronto do not discharge mirex, so remedial measures taken at the waterfront may not provide an edible fishery unless mirex discharges are halted elsewhere. PCBs are present in Toronto's stormwater runoff and in Harbour sediments.

There are aesthetic problems at the waterfront which are mainly caused by debris and algae found floating around the water front. The RAP Team believes that the debris could be remedied by the SCOUR program which currently runs during the summer months in Ontario.

Cost Estimates

All four water quality objectives were estimated for Metropolitan Toronto. The costing for Metropolitan Toronto was derived from RAP documents or Ministry of the Environment documents. The costing for Metro includes costs of remediating the Don and Humber Rivers, but does not include any costs of remediating Mimico Creek. The costs which are estimated for the Humber are based on some remedial actions which are basin wide and others which are pilot projects at selected locations. Therefore the costs estimated for the remediating the Humber River underestimate the total costs of remediation.

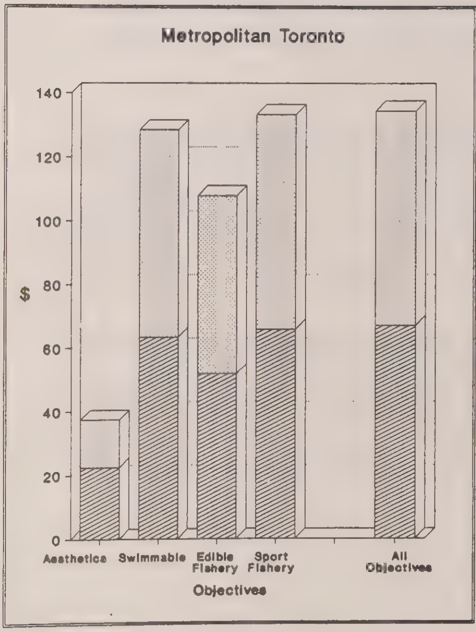
The major water quality problem in Metropolitan Harbour is caused by the discharge of approximately 2100 storm sewers which discharge into the lake's tributaries. Thus it is not surprising that just over 95% of the costs of remediating Metro Toronto's waterfront are due to urban runoff.

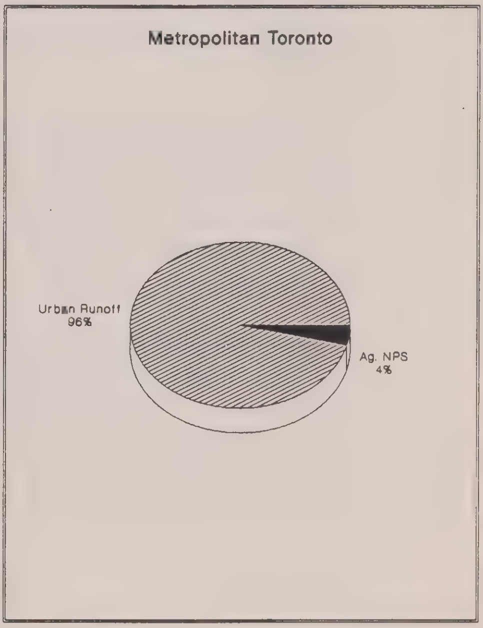
The capital costs of remediation are printed in the source documents as ranges. The estimated annual capital costs of achieving all four water quality objectives in Metro Toronto are $62 to $67 million, with annual operating and maintenance costs being an additional $56 to $67 million.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital | Annual O & M





THE NIAGARA RIVER

The Niagara River connects Lake Erie with Lake Ontario and forms the international boundary between Canada and the United States. It is used as a source of drinking water, for industrial process and cooling water, as a source of energy, as a major tourist attraction, and is used as a receiver of the discharges and waste from industries and municipalities along its shores.

The major problem in the Niagara River is toxic substances and their potential effects on human health and the ecosystem. Water quality criteria are exceeded in the Niagara River for heavy metals and various organic compounds. As well, sediments in the Niagara River are contaminated by many years of discharges with conventional pollutants, heavy metals, industrial organic chemicals, PCBs and pesticides.

Information on toxics has been assembled by the Niagara River Toxics Committee which provides loading estimates from various point sources along the river.

The river has high levels of bacteria attributed to the CSOs, STPs and urban runoff in the area. This high level of bacteria impairs swimming in the river. Some of the larger fish in the river are restricted for eating due to the levels of mercury, PCBs, Hexachlorbenzes, and Octochlorostyrenes found in the fish. The presence of toxics in the fish in the river also impairs the areas sportfishery. Aesthetics in the area are also impaired.

There are three STPs on the Ontario side of the river which contribute to the bacteria and heavy metals being discharged into the river. The industrial point sources of pollution responsible for discharging heavy metals and toxics into the river include Atlas Steel, Cyanamid (both the Welland and the Niagara Falls plants), Fleet Manufacturing, Ford Glass Plant, B.F. Goodrich, and the Steelpipe Welland Tube Works.

Cost Estimates

All of the cost estimates for the Niagara River were derived by the consultants. No estimates of agricultural non-point source control were made, nor were estimates of contaminated sediment removal or hazardous waste treatment. This was because not enough baseline information was available to allow estimates to be made. This lack of costing information would underestimate the costs of achieving all four water quality objectives in the River.

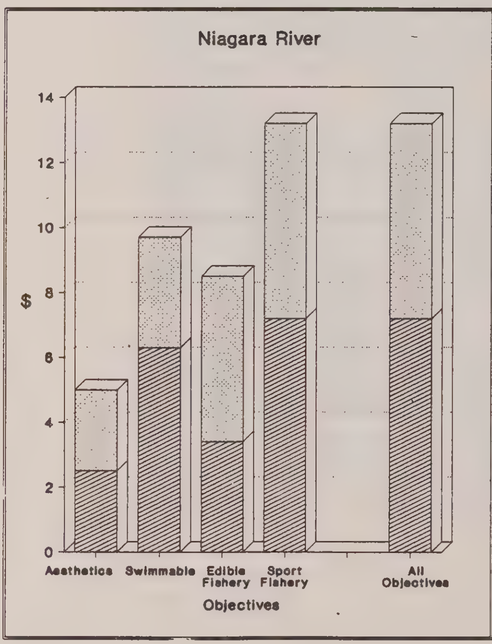
Of the three categories of dischargers which were costed, urban runoff and STPS had slightly higher costs than industries. STP costs were high because both plants which discharge into the Niagara have only primary sewage treatment and the costs of upgrading them to secondary were large.

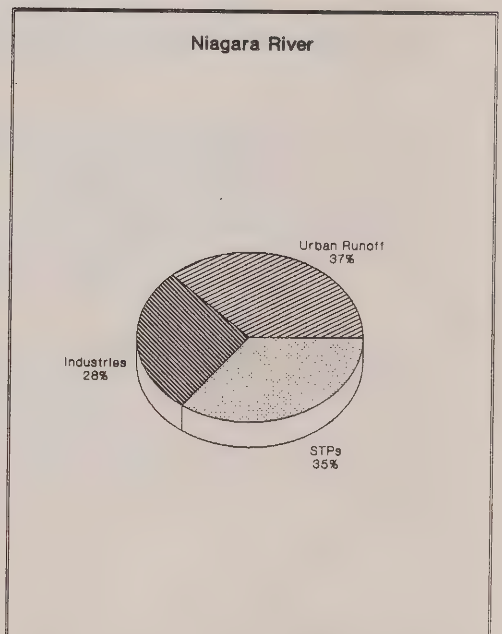
Annual capital costs for Niagara River are estimated to be $7.2 million, while the annual operating and maintenance costs are estimated to be an additional $6 million.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital — Annual O & M





NIPIGON BAY

Nipigon Bay is located at the northernmost point of Lake Superior. Nipigon, a town of 2,500 people, and Red Rock, a town of 2,650 people are both located near the mouth of the Bay.

Nipigon Bay receives municipal wastewater from these two small towns, as well as the effluent from Domtar Packaging Ltd. Effluent from these sources have resulted in occasional taste problems in drinking water and fish flesh, and the presence of toxic contaminants in surface waters and sediments.

Fish consumption advisories exist for yellow perch, lake trout, and whitefish which impairs the area's edible fishery. The effect that the warm water temperature of the effluent plume from Domtar has on the sportfishery is still unknown. Aesthetics in the area are impaired by the effluent plume from Domtar. Swimming in the area is also an impaired water quality objective.

The District of Red Rock STP discharges heavy metals and toxics into the waterbody. It is the only STP which discharges effluent directly into the bay. Domtar is the only industry which discharges effluent directly into the Bay. As well as conventional pollutants, Domtar discharges toxics and heavy metals into the water.

Costing Information

All four water quality objectives were costed for Nipigon Bay by the consultants. BAT costs were not available for the Domtar pulp and paper mill.

The costs for remediating the STP at Red Rock were twice as much as remediating the urban runoff. This is because the STP currently has only primary treatment and it must be upgraded in order to meet the definitions of achieving swimmable water and a sportfishery.

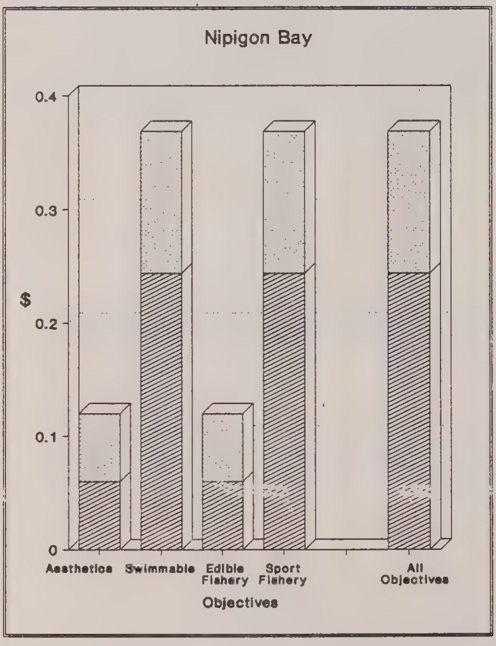
The costs for achieving an edible fishery underestimate true costs of remediation due to the fact that no BAT costs were available for Domtar. For the sportfishery, costs are also underestimated because the costs of removing toxics from Domtar's effluent are not available.

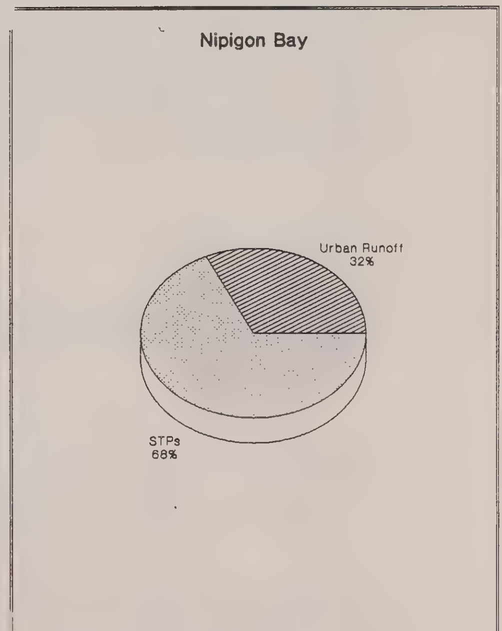
It is estimated that the annual capital costs for achieving all four water quality objectives in the Bay will be $240,000, with annual operating and maintenance costs estimated to be $125,000.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital   Annual O & M





PENINSULA HARBOUR

Peninsula Harbour is located on the northeastern shore of Lake Superior, 300 km east of the City of Thunder Bay. Water quality surveys in the area indicate that there are toxic contaminants in the fish and bottom sediments.

Consumption restrictions exist for lake trout for organic contaminants (PCBs) for fish greater than 65 centimetres in length. There are also mercury consumption restrictions primarily for suckers (white, longnose and redhorse). Restrictions also exist for mercury and PCB's in whitefish. Restrictions on these fish are based on 1986 data and it is expected that concentrations in younger fish have decreased since this time, although consumption limits may continue to exist for larger, older fish.

Mercury contamination in sediments continues to be a problem in the area. Sediment studies conducted in 1989 will serve to delineate both the areal and depth extent of the problem. Remedial options for the contaminated areas will be decided based on these results and the recommendations of the RAP team and the Public Advisory Committee.

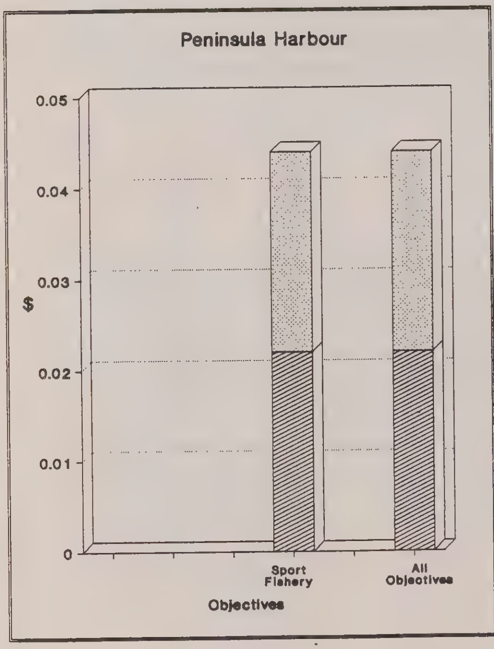
Cost Estimates

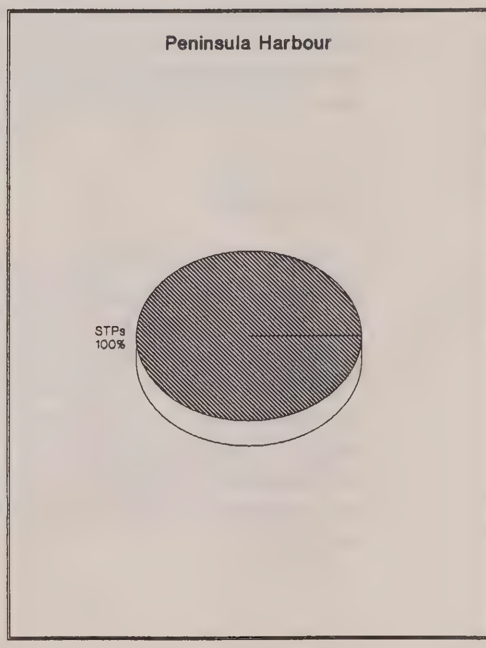
Although both edible fishing and sportfishing are impaired water quality objectives in Peninsula Harbour, only the costs of achieving sportfishing have been costed. The costs of remediating sediment could not be estimated because it is not determined whether sediments will be removed or left buried in the waterbody. Costs of controlling urban runoff were not estimated because the RAP team suggested that the pollution from this source was minimal. The only remedial option which was estimated was the cost of additional phosphorus removal at the Marathon STP. Depending on what is decided by the RAP team for sediment remediation, costs may or may not be understated.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital — Annual O & M





PORT HOPE

Port Hope Harbour is located at the mouth of the Ganaraska River on the north shore of Lake Ontario, approximately 100 kilometres east of Toronto.

Approximately 90,000 cubic metres of sediments in the Harbour are contaminated by uranium and thorium series radionuclides, heavy metals, and PCBs. Contamination is believed to be primarily the result of waste management practices associated with radium and uranium refining operations in the town of Port Hope from 1933 to 1948.

Due to the radioactive nature of the contaminated sediments in the Harbour, the sediments have been designated by the federal government as historic low level radioactive waste. Historic low level radioactive wastes are the responsibility of the federal government.

A large amount of recreational fishing takes place in the Port Hope area, however no fishing takes place in the Harbour proper. Because of the waterbody's shallow depth and configuration, the turning basin experiences high summer water temperatures, low dissolved oxygen content and murky waters. These characteristics of the Harbour discourage many fish species form entering the basin.

Cost Estimates

To remediate the Harbour, the RAP team is considering both in-situ management options and sediment removal options that meet the water quality objectives for the Harbour. If the harbour is to continue to be used as a small craft harbour, the contaminated sediment will need to be removed. Other remedial options such as in-situ measures can be considered if the harbour uses change in the future.

Annual capital costs of dredging ranged from $150,000 to $650,000[3], while annual capital costs of capping were estimated to range from $100,000 to $140,000. There were no operating and maintenance costs associated with these options. The annual capital costs of dredging appear in the bar chart shown for Port Hope.

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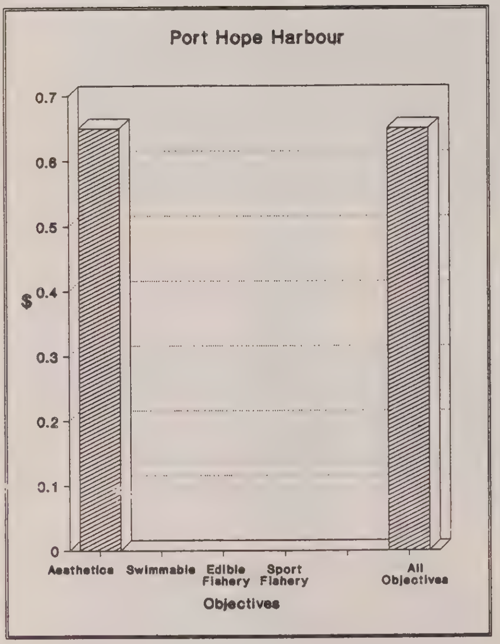
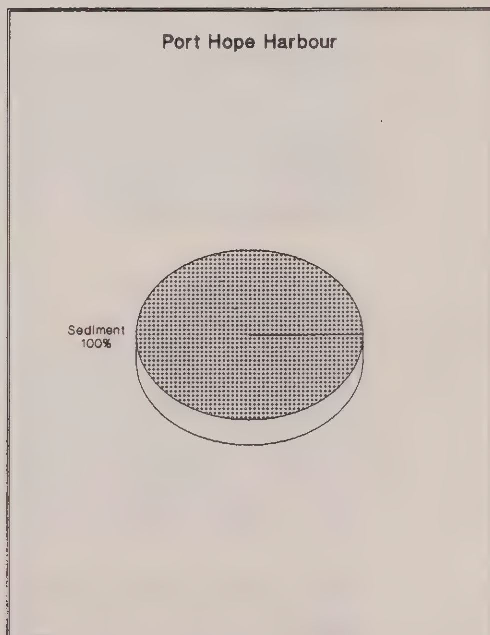
[3]Costs of dredging estimated by Maclaren Engineers, Canadian Dredge and Dock Inc., and Golder Assoc., 1987 in "Port Hope Remedial Program - Conceptual Engineering Design for Harbour Clean-up", Report No. 3 to the low-level Radioactive Waste Management Office.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital | Annual O & M





ST. CLAIR RIVER

The St. Clair River flows in the southerly direction forming an international boundary between the United States and Canada. Contaminant problems specific to the St. Clair include sediment contaminated with PCBs, oil and grease, mercury, and other metals, and fisheries affected by PCBs and mercury.

Bacteria from the STPs, CSOs and urban runoff from Sarnia all contribute to impairing the water in some areas for swimming. Toxics in the water, specifically mercury and PCBs are found in larger fish in the river and impair the area's edible fishery. The sportfishery in the river is hampered by a poor habitat.

The two STPs on the Canadian side of the river are sources of toxics and heavy metals into the river. A number of petrochemical industries are located on the Ontario side of the river. These plants discharge PCBs, heavy metals, and other toxics into the waterbody. Urban runoff from Sarnia is also a source of pollution, with conventional pollutants, heavy metals, and toxics all running into the St. Clair.

There is a large agricultural area which also drains into the St. Clair and which is a source of phosphorus, ammonia, and pesticides. There are sixteen hazardous waste sites within the drainage basin of the Ontario side of the St. Clair River. Three sites in particular, Dow Chemical on Scott Road, Polysar Limited on Scott Road, and P & E Oil Recyclers in Petrolia are Priority One Sites which means they have a potential for impact on human health and safety. Aesthetics in the area are also impaired.

Cost Estimates

The consultant team derived all of the costs associated with remediating all four water quality objectives for the St. Clair River. No information was available on the hazardous waste sites along the St.Clair, nor was BAT cost information available for CIL.

Costs for the STPs for the St. Clair are large because both plants were costed for improving treatment from primary to secondary. As a percentage of total costs, the STP costs are by far overshadowed by the BAT costs for four industries in the organic chemical sector which were derived. These costs are responsible for ninety percent of the total costs of achieving all four water quality objectives in the St. Clair.

Annual capital costs for achieving all water quality objectives in the St. Clair are estimated to be \$26.1 million with additional annual operating and maintenance costs estimated to be \$48.6 million. These cost estimates are low because there was insufficient information to cost the remediation of the hazardous waste sites.

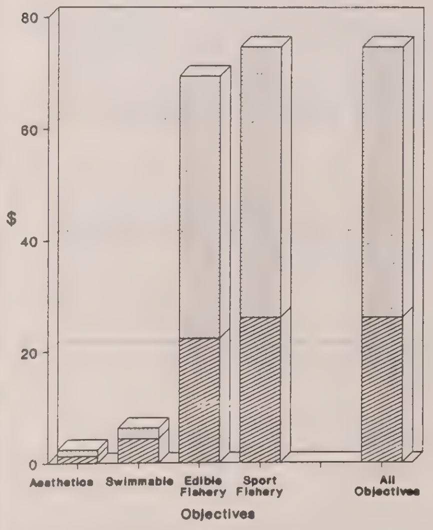
Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

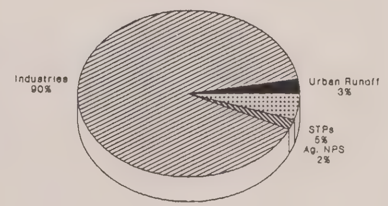
Annualized Capital

Annual O & M

St. Clair River



St. Clair River



ST. LAWRENCE RIVER

The St. Lawrence River Area of Concern extends form the Moses-Saunders Power dam to the eastern outlet of Lake St. Francis. This includes St. Lawrence River water claimed by Ontario, Quebec, New York State, and the Mohawk people.

While the entirety of Lake St. Francis is considered in the RAP, this study provides estimates of costs and benefits associated only with Ontario. This is consistent with the Canadian RAPs' focus on the remediation of Ontario sources and resulting impacts, although the RAP Team is not restricted to Ontario waters in its assessment of conditions, sources, nor the identification of remedial actions.

PCBs and mercury are present in larger fish in the St. Lawrence and the consumption of these fish is restricted. Researchers examining the St. Lawrence believe that the toxics in the fish are due the multiple sources: contaminated suspended material coming from upstream, local dischargers, and food chain transfer.

The aesthetics of the St. Lawrence are impaired due to excessive aquatic weed growth and odours. Rooted aquatic weeds and masses of uprooted aquatic weeds can create nearshore, localized water quality, odour, and aesthetic impairment. Some industrial effluents are malodorous and therefore unpleasant to boaters in the area of the discharge.

The City of Cornwall STP is the only STP on the Ontario side of the river. It discharges large amounts of phosphorus as well as small amounts of phenols and mercury. There are five industrial plants which discharge their effluent through two discharge pipes into the river. The effluent pipes of the industries discharge conventional pollutants as well as mercury and phenols into the waterbody. Urban runoff from the Cornwall area contains bacteria, PCBs, Pesticides, toxics, and heavy metals.

Swimming is impaired because of the high levels of bacteria in some parts of the river.

Hotspots in the sediment occur where there are high concentrations of mercury such as the area in front of the City of Cornwall or near Courtaulds shoreline. These areas may require some remedial action.

Cost Estimates

The consultant team derived all costs achieving the four water quality objectives for the St. Lawrence River. Estimates of the volume of sediments to be remediated, are not available. As well, BAT costs for Domtar Fine Papers were not available.

The City of Cornwall STP accounts for about forty percent of the costs of remediating the sites. This high cost is due to the fact that at present, the plant only has primary treatment and, in order to achieve swimming and edible fishery, it must be upgraded to secondary treatment.

Urban runoff and industry account for the next two largest costs for remediation. The St. Lawrence River has a large agricultural basin which drains into it and thus it is not surprising that costs for controlling agricultural non-point sources of pollution are responsible for almost twenty percent of the total costs.

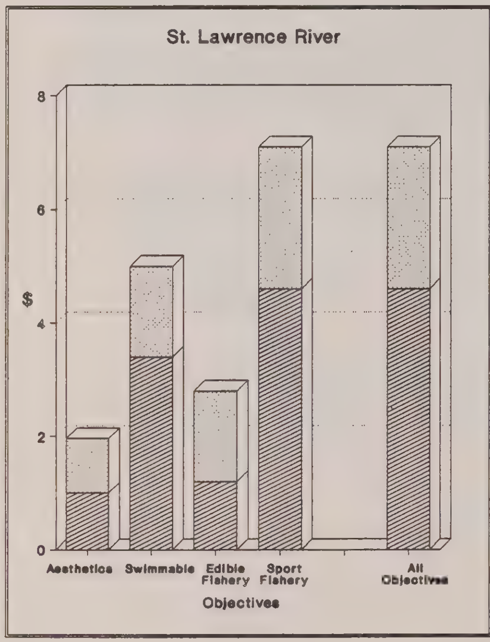
Annual capital costs for achieving all water quality objectives in the St. Lawrence are estimated to be $4.3 million, with additional annual operating and maintenance costs estimated to be $2.5 million.

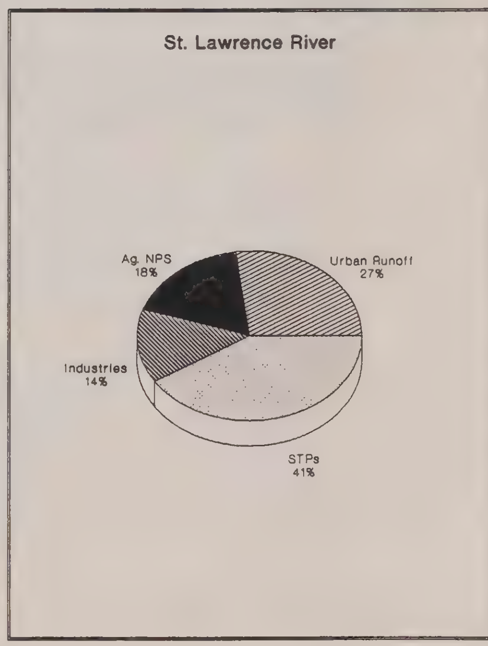
Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital

Annual O & M





ST. MARYS RIVER

St. Marys River is one of the channels which connects the Great Lakes. As such, approximately one-half of the River belongs to the United States. Zones of degraded water quality downstream of Sault Ste. Marie are high in iron, phosphorus, fecal coliforms, phenolics, and benzopyrene. Researchers examining St. Marys are concerned about:

- the combined effects of ammonia, cyanide, and heavy metal concentrations in the river which may result in toxic conditions in some parts of the river;

- excessive amounts of oil and grease as a result of discharges or spills; and

- PAHs (which are carcinogenic) which are found in certain areas of the river.

Swimming in the river is impaired because of turbidity and because of the high levels of bacteria and fecal coliforms found in the river. Mercury and PAHs have been found in some of the larger fish in the river and impairs the areas edible fishery. There is a sportfishery which exists in the river which has a poor habitat for reproducing due to the constant dredging of the river which is required for shipping.

Occasionally, aesthetics is a problem in the St. Marys when mats of oily fibrous materials mixed with wood chips can be seen from the Sault Ste. Marie waterfront to the Lake George channel. These intermittent problems are due to the decomposition of fibres and wood particles prevalent in the river sediments along the Canadian shoreline.

Degradation in the River is due to Algoma Steel, the St. Marys paper mills, and municipal sewage treatment plant discharges in Canada. On the U.S. side, combined sewer overflow discharges contribute to impairment of the water body.

Two sites have been identified as suspected sources of urban non-point contamination into the river. These include a 400 ha slag disposal site on the Canadian shore upstream of the locks, and an abandoned waste disposal site on the American shore which, up until 1955, was operated by a tannery. Sediment surrounding the first disposal site are contaminated with PAHs and heavy metals, while at the second site heavy metal contamination, cyanide leaching, and erosion have been identified as problems.

Cost Estimates

All costing for the four water quality objectives for the St. Marys River was derived by the consultants. There were no estimates of hazardous waste to be treated or sediment which may need to be removed. Estimates were also not available for agricultural non-point source pollution and BAT costs for St. Marys paper.

The costs for remediating St. Marys River are essentially split three ways between STPs, Urban Runoff, and Industries. Over 90% of the cost allocated to the STPs are from upgrading the Sault Ste. Marie STP from primary to secondary treatment. The industry portion of the cost, estimated to be 29% is all allocated to BAT costs for Algoma Steel.

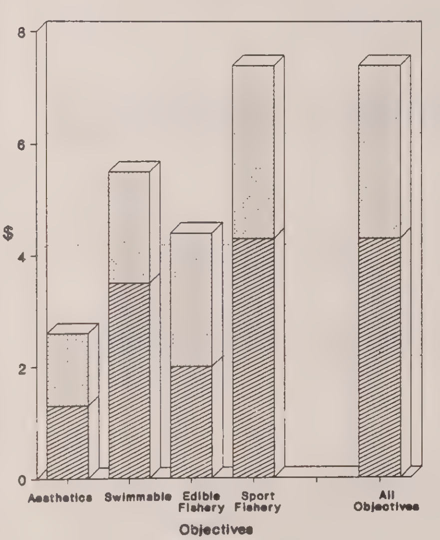
Annual capital costs for achieving all four water quality objectives is estimated to be $4.3 million, with additional operating costs of $3.1 million.

Remediation Costs for RAP Sites

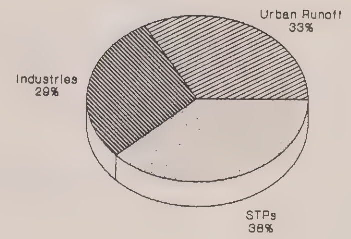
(Millions of 1989 Dollars)

Annualized Capital   Annual O & M

St. Marys River



St. Marys River



SEVERN SOUND

The Severn Sound is a complex of shallow bays in the south-east part of Georgian Bay. The shoreline development around the sound includes the Towns of Midland and Penetanguishene, as well as rural land and cottages.

There is excessive algal growth in the Sound due to high levels of phosphorus found in the waterbody. This algal growth impairs swimming in the waterbody because of the unsightliness of the algae and because the turbid water that results because of the algae. Aesthetics in the Sound are also impaired because of the algal growth.

There is a sportfishery which exists in the Sound, however consumption of walleye and smallmouth bass is restricted due to mercury contamination which impairs the area's edible and sport fisheries.

High phosphorus loadings in the Sound are a result of phosphorus loadings from a number of sources:

- six STPs which discharge directly into the Sound and an additional three STPs which discharge into tributaries of the Sound;
- watershed runoff;
- sediment release;
- release from shoreline development and stream bank erosion from the Wye River and Hog Creek; and
- precipitation.

There is one industrial plant which discharges chromium and fluoride into the Sound and which is currently meeting Provincial objectives for those pollutants. Sediments in the Sound contain copper, chromium, lead, zinc, and solvent extractables which currently exceed the MOE Open-Water Disposal Guidelines.

Cost Estimates

Cost estimates for achieving the four water quality objectives were derived by the consultants.

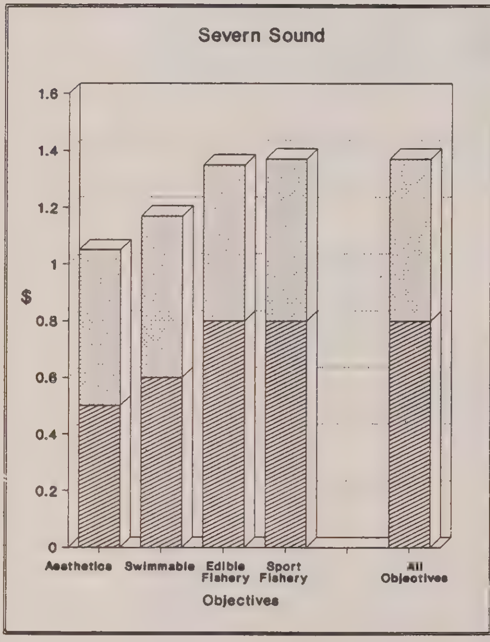
The majority of the costs for Severn Sound are for urban runoff control. Eutrophication is the Sound's main problem, and urban runoff control will decrease phosphorus and improve the water quality. Additional phosphorus removal was also costed for the four STPS, however these costs are dwarfed by the costs of urban runoff control.

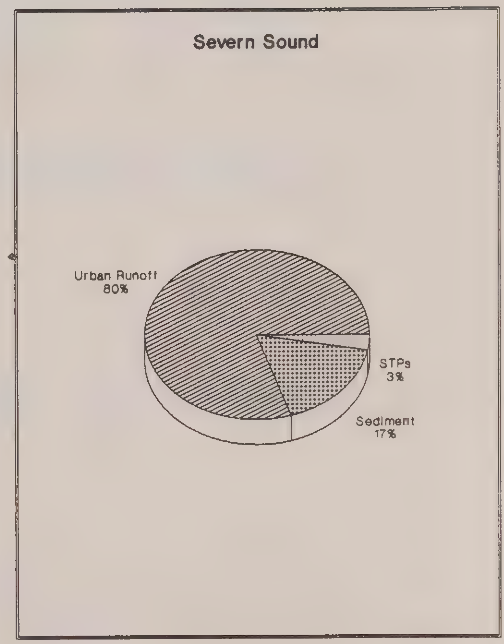
Annual capital costs for achieving all four water quality objectives are estimated to be $800,000 with additional annual operating and maintenance costs estimated to be approximately $560,000.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital | Annual O & M





SPANISH RIVER

The Spanish River flows southerly towards the Northern Channel of Lake Huron and discharges south of the Village of Spanish (which is in the geographic district of Sudbury).

The Spanish River was originally designated an area of concern because of tainting of fish flesh, depressed benthic fauna, and indications of nutrient enrichment in the Harbour , however these issues have since been resolved. Swimming is impaired, but only in a narrow zone of non-compliance (mixing zone) immediately downstream of the Espanola WWTP. The zone of impact is limited to a reach of river where use, even in the absence of criteria violations, would be non-existent.

Data collected in 1988 documented mercury concentrations in walleye less than 1.5 kg. to less than the consumption guideline. However, further data is required to assess the status of perch greater than 30 cm which historically exceeded the guideline.

Sediments at the confluence of the river and the adjacent Whalesback Channel exceed openwater disposal guidelines for metals. However, the ecological impact of this is un-defined. Assessment data collected in 1988 supports substantial recovery of the nearshore benthic communities and a detailed statistical assessment could not relate impairment of the benthic community to sediment contamination.

PCBs were historically elevated above the openwater disposal guideline, but have never been show to bioaccumulate in juvenile or adult fish. Present day surface concentrations are less than the disposal guideline, but historical deposits may be buried at depth.

Cost Estimates

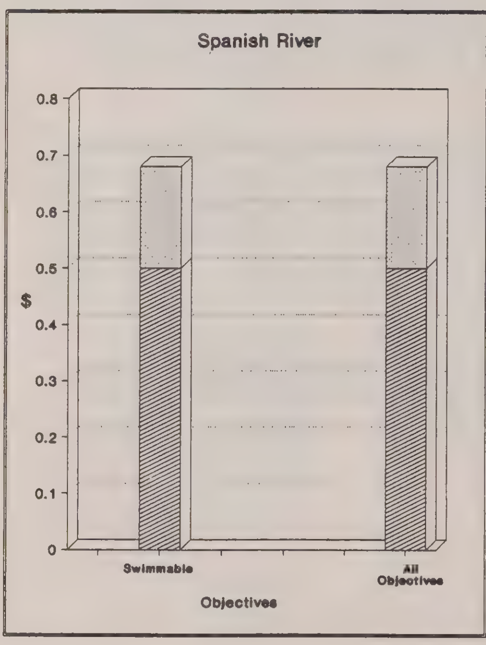
Cost estimates for achieving swimmable water were derived by the consultants.

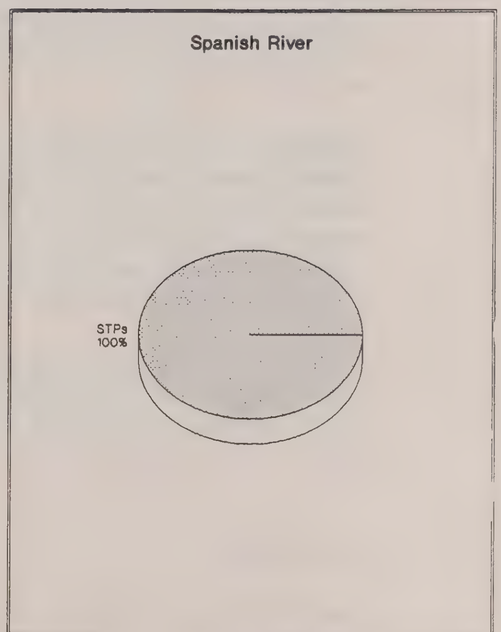
In order to reduce bacteria and nutrient enrichment in the river, upgrading the STP from primary to secondary treatment was costed. Annual capital costs for achieving the water quality objective of swimming are estimated to be $500,000. Annual operating and maintenance costs are estimated to be $180,000.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital — Annual O & M





THUNDER BAY

The City of Thunder Bay is the largest Canadian city on Lake Superior. As the world's largest grain handling port and the second largest port in Canada, approximately 1000 lake and ocean-going ships travel to Thunder Bay Harbour annually to tranship millions of tons of cargo.

Swimming in some areas of the Bay and some tributaries is restricted because of high levels of fecal coliforms as well as cold water conditions. Larger fish in Thunder Bay are contaminated with mercury, and consumption guidelines exist for lake trout, northern pike, walleye, and white sucker which impairs the area's edible fishery. The sportfisheries habitat, in particular lake trout and chinook salmon, is considered to be threatened by historic as well as present pollution problems.

The water quality in the lower Kaministiquia River, which flows into Thunder Bay, is often not good enough to allow fish movement to and from spawning areas and habitat in the upper section of the river. Aesthetics in the area are also a problem.

Dischargers of pollutants into Thunder Bay include the Thunder Bay STP, Canadian Pacific Forest Products mill, Northern Wood Preservers, Ontario Hydro, three Abitibi-Price Inc. mills, Ogilvie Mills (flour processing), and Reichhold Chemicals. Urban runoff from Thunder Bay, agricultural non-point sources, and contaminated sediments all contribute to a lesser extent the pollution in the Bay.

Cost Estimates

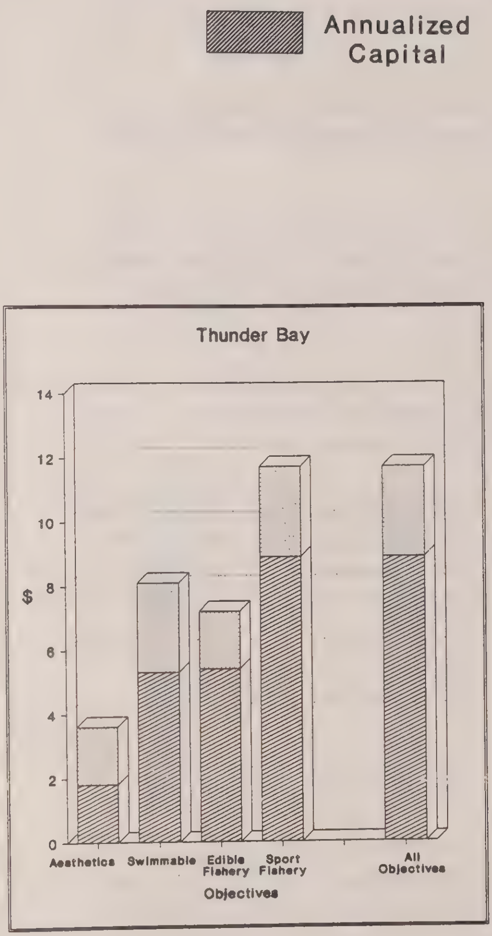
All costs for Thunder Bay were derived by the consultants. The costs for Thunder Bay as they are reported are significantly lower than what they actually will be if all four water quality objectives are achieved. This is because certain BAT costs were not available for a number of industries. The industries which were not costed for toxics removal are Canadian Pacific Products, Northern Wood Preservers, and Abitibi Price's three pulp and paper mills.

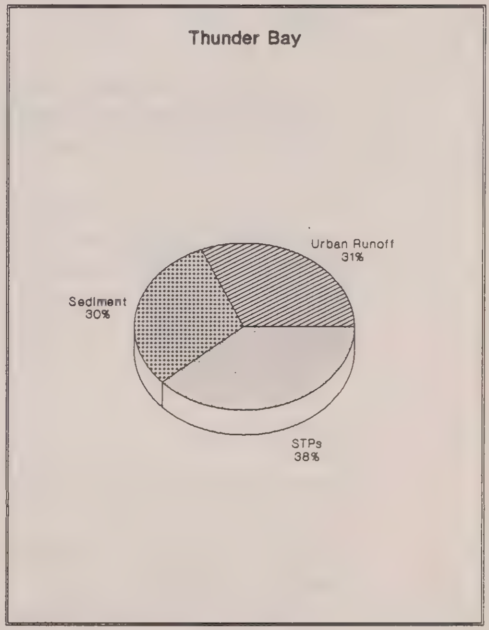
Of the costs which were formulated, upgrading the Thunder Bay sewage treatment plant from primary to secondary treatment accounted for 38% of the total costs. Sediment removal in front of the Northern Wood Preservers plant accounted for another 30% of the costs. Urban runoff was responsible for approximately 30% of the costs.

Annual capital costs for achieving all water quality objectives in Thunder Bay are estimated to be $8.9 million, while annual operating and maintenance costs are estimated to be $2.8 million.

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)





WHEATLEY HARBOUR

Wheatley Harbour functions as the major Canadian fish processing port for the western and central basins of Lake Erie. Approximately 45 commercial fishing tugs use Wheatley Harbour as a port for offloading their catch to the local fish processing operation. The Harbour has a healthy commercial fishery including bait species.

Wheatley Harbour was classified as an Area of Concern because of oxygen depletion, elevated bacteria levels, nutrient enrichment and organic and PCB contamination of Harbour sediments.

Swimming in the Harbour is impaired due to the bacteria from Omstead Foods (a fish processing plant) and due to the turbidity of Harbour sediments caused by the incoming and outgoing fishing boats and a large number of carp.

Over the years remedial actions in the Harbour have improved the water condition to levels that approach typical ambient concentrations for the county in which it is located (Essex County).

The Harbour area is dredged annually for fishing tug navigation removing some of the PCBs present in sediments in the main part of the Harbour. There are still PCBs in the wetlands, however these do not appear to leach back into the water column. Removal of the PCBs from the wetlands could impair the wetlands.

Cost Estimates

All cost estimates for Wheatley Harbour were derived by the RAP team.

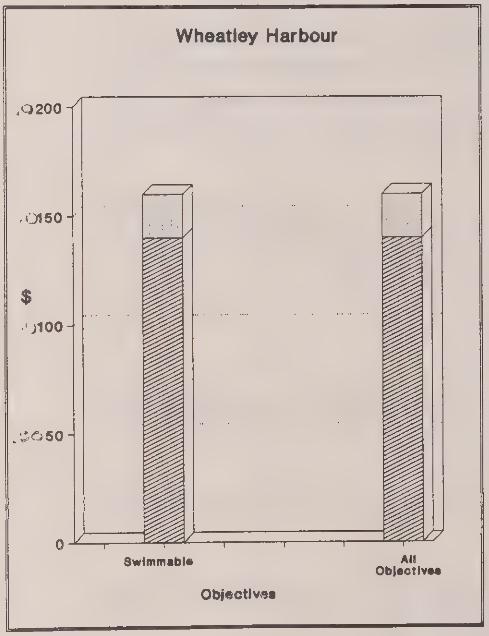
The main problem in Wheatley Harbour is bacteria contamination from a local food processor, Omstead Foods. The annual capital costs of ultra-violet treatment of the plant effluents have been estimated to be approximately $13,500. Operating and maintenance costs for the treatment are estimated to range from $900 to $1600.

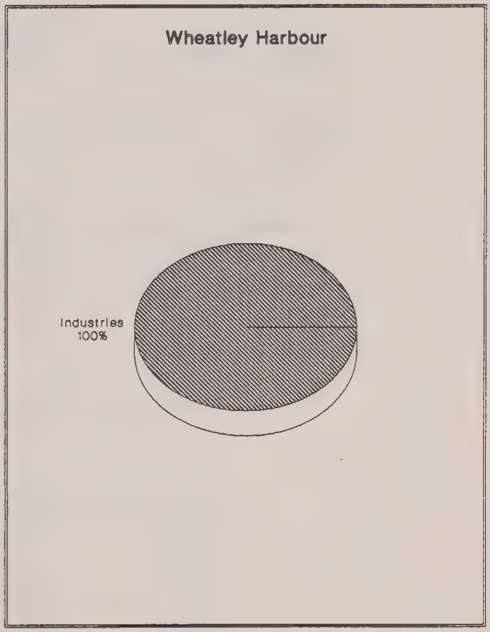
Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

Annualized Capital

Annual O & M





ALL RAP SITES

The annualized capital costs for achieving all water quality objectives across all 17 RAP sites are estimated to be $150 million. In addition to this, annual operating and maintenance costs would be $150 million.

It is interesting to note that the cost of achieving all water quality objectives at all of the RAP sites is only 5% higher than achieving a sportfishery at all sites. This is because in order to achieve a naturally reproducing sportfishery, almost all remedial options for the site must be carried out.

It is also not surprising that the largest component of the costs (53% of the total) for achieving all water quality objectives is urban runoff control, a remedial option which was costed in all but four of the RAP sites.

Expenditures on remedial actions by industries make up 28% of the costs. This estimate is low because BAT costs were not available for certain types of industries. For example, none of the kraft pulp mills were costed for removal of toxics. As well, BAT costs were available for only one of the three plants in the inorganic chemical sector.

The third largest component of the costs is sewage treatment plants. The largest component of these STP costs are the eleven plants which were required to move from primary to secondary treatment.

The following three exhibits present:

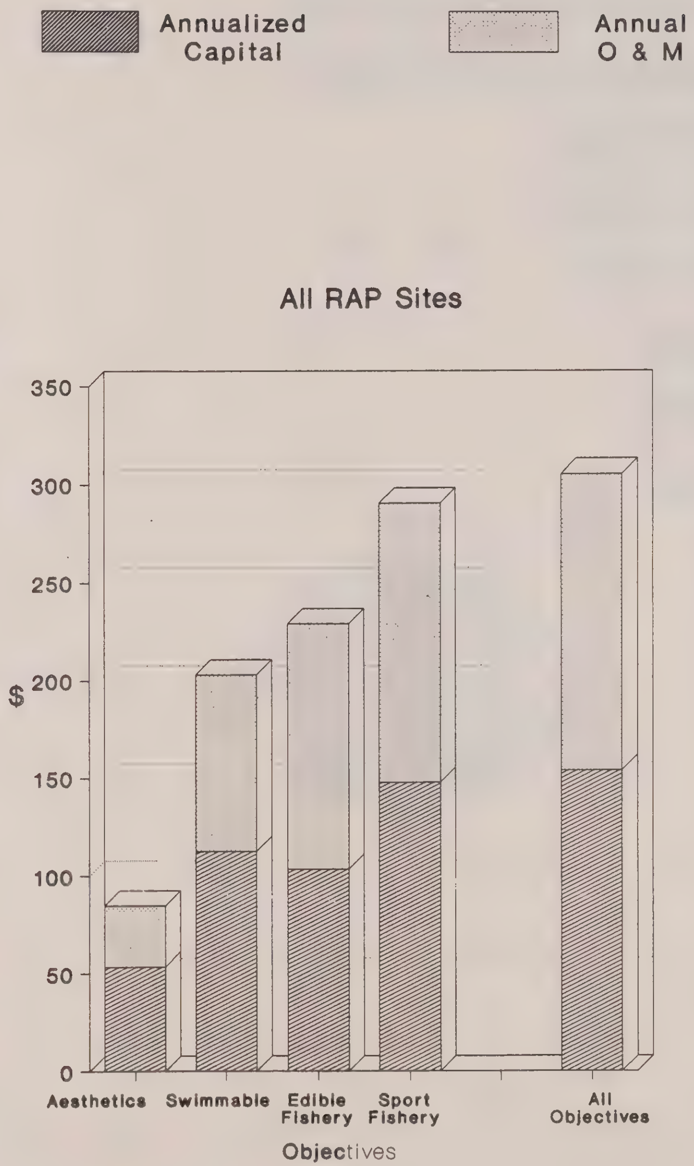
- the remediation costs for bringing all RAP sites up to each of the water quality objectives;

- the total remediation costs for all RAP sites broken down by source of pollution; and

- present values of the capital costs of achieving all water quality objectives at each site.

Remediation Costs for RAP Sites

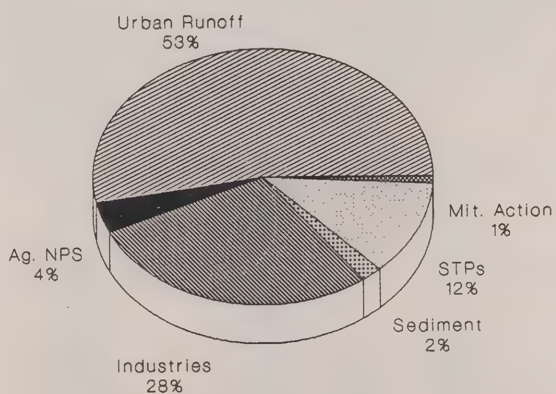
(Millions of 1989 Dollars)

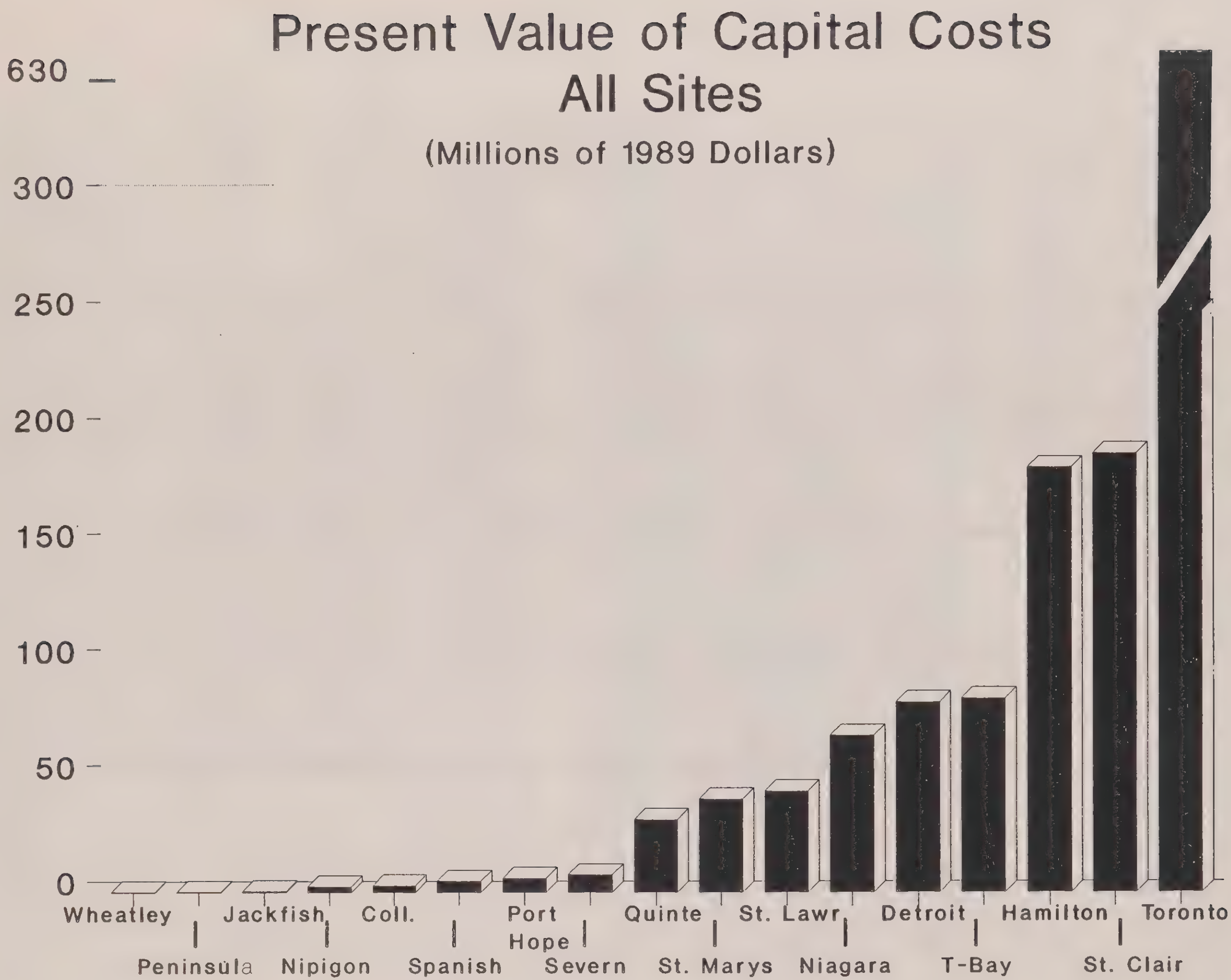


Remediation Costs for RAP Sites

(Millions of 1989 Dollars)

All RAP Sites




Present Value of Capital Costs
All Sites
(Millions of 1989 Dollars)
630
300
250
200
150
100
50
0
Wheatley
Peninsula
Jackfish
Nipigon
Coll.
Spanish
Port Hope
Severn
Quinte
St. Marys
St. Lawr
Niagara
Detroit
T-Bay
Hamilton
St. Clair
Toronto

5.0 ESTIMATION OF ECONOMIC BENEFITS

INTRODUCTION

STRUCTURE OF SECTION

The four water quality objectives which have been enunciated for the 17 RAP sites describe water which is:

- swimmable;
- able to support an edible fishery;
- able to support a self-sustaining sportfishery; and
- aesthetically pleasing.

These objectives are defined in Chapter 3 of this report.

This chapter of the report describes the economic benefits of achieving each of these objectives at each of the 17 RAP sites. The chapter is structured as follows:

- The remainder of this section briefly describes the theory behind estimation of economic benefits, defines the concept of "target area", and delineates the target areas used in this study.

- The next section then describes the current uses, and levels of use where data are available, of relevant activities at each of the sites and the projected increases which will take place in these activities if the water quality is improved.

- The third section develops estimates of the use value - that is, the economic value to recreationists - associated with achieving the four water quality objectives at each of the sites.

- The fourth section then provides estimates of the non-use value - that is, the economic value accruing to non-recreationists - of improving water quality at the RAP sites. These estimates are provided for each of the RAP sites and for the province as a whole.

- The results of the previous two sections are then combined to estimate the total economic value associated with achieving the four water quality objectives.

- The final section then describes the economic impact - that is, the income and employment - which will be associated with achieving the water quality objectives.

Two Approaches To Measuring Economic Benefit

Improving water quality requires investment in a set of remedial or mitigative measures. (These have been described and costed in the two preceding chapters of this report.) These investments give rise to economic consequences which can be measured in two different ways. One approach attempts to measure the "welfare" or "economic value" benefits which accrue to the residents around the sites, or in the province as a whole, from engaging in new or more enjoyable recreational activities as a result of the improvement in water quality, and from simply knowing that the water is cleaner. The second approach involves measuring the "economic impacts" arising from expenditures made in implementing, operating, and maintaining the control measures, and from expenditures associated with new or increased recreational activity which occurs as a result of their implementation. (These two approaches are described in detail in Appendix D and E.)

Economic value - also known as "consumer surplus"[4] or "net willingness-to-pay" - is the measurement of value which is consistent with the concept of "benefit" in benefit-cost analysis. The studies which have been done to evaluate changes in water quality have, collectively, identified the following types of economic value associated with these changes:

- "Use value", which is the increase in welfare to people who actually "use" the water, for example, for sportfishing or swimming. Calculation of use value requires estimating the number of new recreation days and the economic value associated with the new activity. In addition, an increase in use value may arise from enhancing the existing recreation days.

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[4]"Consumer surplus" refers to the value which accrues from consumption of a particular good or services, over and above the cost associated with its consumption. A more detailed explanation is provided in Appendix D.

- "Non-use" or "intrinsic" value, which accrues to residents simply from knowing that the water is cleaner and that they (or their descendants) could participate in new or enhanced recreational opportunities as a result.

Ideally, estimation of these values should be based on a survey of residents at each site to determine their "willingness-to-pay" (WTP) for certain recreational opportunities and for given levels of water quality. However, the time and resources available in this study precluded primary data-gathering. Instead, estimates of economic value have been derived from studies of other water bodies both in Canada and the U.S. Judgement has been applied to these results to adjust for differences between circumstances in the areas studied and those at the RAP sites. However, it should be emphasized that transferring results from one study or group of studies to another may be inappropriate.

Use of secondary data in this study for calculating use and non-use values, as well as the lack of data for many of the RAP sites on current and projected activity levels, means that estimates of economic value in this study should be regarded as "order-of-magnitude" estimates. (This is particularly true for the non-use component of economic value, since this is a relatively new area of economic research, with many conceptual difficulties yet to be resolved.) The analysis provides an indication of the benefits which can be anticipated from improving water quality at the RAP sites, and a framework for estimating the benefits more precisely should better data become available.

Delineation Of Target Areas

In the case of both economic value and economic impact analysis, it is necessary to define the geographical, or "target", areas for which effects are to be calculated. In the case of economic value analysis, by definition only the increased welfare accruing to residents of the target area is relevant. In the case of economic impact analysis, again by definition, income and employment which occurs within the target area as a result of water quality and recreational expenditures are relevant; income and employment occurring outside the target area are not relevant.

Identification of the target areas is an important step in both the analysis of economic value and the estimation of economic impact. However, unless a primary survey of each RAP site were to be conducted, within predetermined boundaries, the specification of target areas is somewhat arbitrary. The studies from which estimates of use and non-use values are drawn (as described in later sections) are based on surveys of residents and

recreationists for target areas of varying sizes. For example, one study asked a sample of respondents across the United States how much they would be willing to pay to clean up all rivers and lakes in the whole country. More local studies limit their surveys to regional or local residents; however, even in these cases the size of the area surveyed varies from study to study.

Furthermore, the area from which users of the site are drawn may not necessarily be consistent with the area which will derive non-use benefits from improving the site. While it would be primarily residents of the RAP sites who would use these sites, it is conceivable that all residents of the province may attach some value to improving conditions at the sites.

In summary, identification of the target area depends on a number of factors, including the nature of the questions being asked and the political basis for the study, and is one reason why transferring results from one study to another is suspect. For the current study, two target areas have been defined.

- The "base case" assumes individual target areas for each RAP site, corresponding to the municipalities in the immediate vicinity of each site. Where the RAP teams have identified an area, this was used. Where this has not been done, the target areas were defined according to the regions from which most of the current and potential users of the sites would likely be drawn. For the most part, these regions correspond to the municipalities bordering the water bodies in question. Target areas were also defined, to some extent, in terms of areas for which population data are available. Target areas for the individual RAP sites are listed in Appendix C.

- The second target area used in this study is the province of Ontario, as a whole.

Use values have been estimated only for the "base case" target area for the following reasons:

- it is assumed that most of the recreationists using the RAP sites will be residents of the sites, and

- it is difficult to estimate the number of recreationists who may be drawn to the sites from other areas of the province.

In the case of non-use values, estimates have been provided both for the "base case" target areas and for the province as a whole. Economic impacts are calculated only for the province, primarily because income and employment multipliers are more reliable at the provincial level than they are at a regional or local level.

Interpretation Of Results

The purpose of this study is to provide an indication of the economic consequences which would flow from achieving the four water quality objectives, described earlier, at the 17 RAP sites. Because current water conditions vary considerably from site to site, achievement of these objectives represents different degrees of improvement in each case. The response to these improvements in terms of increased recreational activity, and the welfare associated with the change in water quality, are directly dependent on current water conditions and on a variety of other factors specific to each site. (Some of the factors which affect recreational activity do not relate to the quality of water. For example, lack of access, water temperature, and conflicting activities restrict use levels at several of the sites.)

In order to estimate economic benefits with precision, an in-depth study of each site is required. The following analysis is based on the best information available within the time and resource constraints of the study; however, it does not purport to be exhaustive. At many of the sites, RAP teams have not yet been able to assemble data on current levels of recreational activity, and only one site was able to provide estimates of projected use, given water quality improvements. Thus, in most cases, increments in recreational activities and the associated estimates of use value are based on regional and provincial recreation patterns and on discussions, sometimes with only one person per site, regarding the likely extent of increase in activities at the sites if water quality were improved. As noted earlier, unit estimates of use and non-use value are based on a review of the literature and may exaggerate or understate benefits from improving water quality at the sites in question.

In summary, the estimates of economic value and economic impact contained in this report should be regarded as indicative. The analysis does, however, provide a framework for estimating the economic benefits of improving water quality at the RAP sites and identifies areas where more research and information are required.

CURRENT USE OF SITES AND PROJECTED INCREASES ASSOCIATED WITH ACHIEVING WATER QUALITY OBJECTIVES

Introduction

The four water quality objectives used in this study are water which is swimmable, able to support an edible fishery; able to support a self-sustaining sportfishery; and aesthetically pleasing. These objectives imply certain recreational activities. In the case of the first three objectives, the activities of swimming and recreational fishing are obvious. However, in the case of the fourth objective - water which is aesthetically pleasing - the associated recreational activities are not so obvious, nor is the research so widespread. This issue is discussed below.

Water which is "aesthetically pleasing" was defined in Section 3 as being lacking in "debris, oil, scum, any substance which would produce an objectionable deposit, colour, odour, taste, nuisance algae or aquatic plants" and having a certain clarity. Depending on the current aesthetic conditions at each RAP site, improved aesthetics might conceivably result in increases in a variety of recreational activities. These include swimming, fishing, boating and other activities directly on or in the water, and "passive" activities such as nature viewing, outdoor education, hiking, picnicking and so on. In the case of swimming and sportfishing, the increased participation which arises as a result of aesthetic improvements achieved in connection with these objectives will be captured in the estimation of economic value associated with these two activities. In the case of the remaining activities, three issues arise:

- The extent of the increase in recreational activities which are influenced by aesthetic conditions will depend greatly on the existing aesthetics of the water. Water which is only slightly or sporadically impaired is likely to have a relatively limited negative impact on non-contact recreational activities.

- There are very few studies which attempt to place a value on activities such as nature appreciation, hiking, etc. The results of the studies which do exist are probably more site-specific and less transferrable to other sites than are results for swimming and sportfishing.

- There are no data at any of the RAP sites regarding current levels of participation in passive activities and, therefore, no basis upon which to estimate the increment which would take place as a result of aesthetic improvements.

The use value associated with aesthetic improvements per se is therefore excluded from the analysis of economic value. This omission probably does not substantially alter the overall results, given our judgement that a substantial portion of the effects of aesthetic improvements will be captured in achievement of the swimming and sportfishing water quality objectives.

For the swimming and fishing activities, interviews were held with officials at the RAP sites in order to determine current levels of activity and the probable increase which would take place if the water quality were improved according to the objectives described earlier. (It is assumed, for the purposes of this analysis, that water quality is similarly improved in U.S. waters adjoining Canadian RAP sites, where this is relevant.) The results are described below.

Swimming

The results for swimming are shown in Exhibit 5-1, overleaf. The Exhibit describes, for each RAP site, the extent to which swimming currently takes place, its quality, and the likely extent of increases in swimming if water quality were improved. Because none of the RAP teams has consolidated data on current levels of swimming activity, these are presented descriptively in Exhibit 5-1 as "minimal", "moderate", or "high", according to information from one or two people knowledgeable about each site. These terms are also used to describe the anticipated increase in swimming activity if water quality were improved, except in the case of Hamilton Harbour for which an estimate of new swimming occasions is available.

For ease of reference, a summary of the information contained in Text Table 5-1 regarding current and projected levels of swimming, is provided in Text Table 5-1, below.

EXHIBIT 5-1

SWIMMING—CURRENT LEVELS AND PROJECTED INCREASES AT RAP SITES

Site	Level of Swimming Which Currently Takes Place	Current Quality of Swimming/Incidence of Postings	Extent of Increase in Swimming if Water Quality Improves	If Increase is Low, Why?
1. Thunder Bay	Minimal	Frequent postings/cold water	Moderate	n/a
2. Nipigon Bay	Minimal	Cold water	Minimal	Water too cold
3. Jackfish Bay	Minimal	Cold water	Minimal	Water too cold
4. Peninsula Harbour	Minimal	Cold water	Minimal	Water too cold
5. St. Mary's River	Moderate	Oil spills, high F.C. counts	Moderate	n/a
6. St. Clair River	High	Occasional closures	High	n/a
7. Detroit River	Moderate	Occasional closures	High	n/a
8. Spanish River	Moderate	Only one public beach	Minimal	Limited access
9. Severn Sound	High	No closures, but algae problems	Moderate	n/a
10. Collingwood Harbour	Minimal	Impaired due to bacteria	Minimal	Swimming not recommended by Public Advisory Committee—Too dangerous due to boats
11. Wheatley Harbour	Minimal	Turbidity, bacteria, boats	Minimal	Too dangerous due to boats
12. Niagara River	High	Algae turns people away, some supply constraints	Moderate	n/a
13. Toronto Harbour	High	75% of beaches closed more than 50% of the time	High	n/a

EXHIBIT 5-1, CONTD.

SWIMMING—CURRENT LEVELS AND PROJECTED INCREASES AT RAP SITES

Site	Level of Swimming Which Currently Takes Place	Current Quality of Swimming/Incidence of Postings	Extent of Increase in Swimming if Water Quality Improves	If Increase is Low, Why?
14. Port Hope	Minimal	No swimming in area of concern	Minimal	Good swimming adjacent to site
15. Bay of Quinte	Moderate	No quality constraints, but water is turbid	Moderate	Strong competition from sandbanks
16. St. Lawrence River	Moderate	Some closures	Moderate	n/a
17. Hamilton Harbour	Minimal	No swimming in area of concern	1.1M swimming occasions[1]	n/a

Note: n/a = not applicable

1 Ontario Ministry of the Environment "Assessment of Proposed Remedial Action Plans for Hamilton Harbour", (April, 1988)

Source: Information from Stage I RAP Reports and RAP Co-ordinators.

Text Table 5-1

CURRENT LEVEL OF SWIMMING	LIKELY EXTENT OF INCREASE	NUMBER OF SITES
Moderate or high	Moderate or high	8
Moderate or high	Minimal	1
Minimal	Moderate or high	2
Minimal	Minimal	6
		17

Of the 17 RAP sites, nine indicated that swimming currently takes place at the site to a moderate or high extent. Eight of these sites indicated that there would be a moderate to high increase in swimming levels if water quality were improved. The ninth site indicated a minimal increase; thus, at this site, the use value associated with achieving swimmable quality water is assumed to be zero.

The remaining eight sites indicated that there is either no or minimal swimming currently at the site. At two of these sites - Thunder Bay and Hamilton Harbour - it is likely that there would be an increase in swimming activity given improved water conditions. At Hamilton Harbour, a report prepared for the Ontario Ministry of the Environment (Reference #I-48)[5] estimates that new swimming activity in the Harbour would total 1.1 million swimming occasions, assuming the development of four beaches in the area. For Thunder Bay, the swimming which currently takes place is limited by frequent beach closures. It is likely that if water quality were improved and postings reduced, swimming would increase accordingly.

At the six remaining sites, it is likely that increases in swimming will be minimal even if water quality is improved. In the case of three of the Lake Superior sites, the water is generally too cold to attract much swimming. (In Thunder Bay, shallow waters make the water warm enough for

[5]References relevant to this Chapter of the report are listed in Appendix I.

swimming.) At Collingwood Harbour and Wheatley Harbour, swimming is considered to be too dangerous due to the high number of boats in the Harbours. At Port Hope, there are good swimming opportunities adjacent to the site and, therefore, no demand at the site itself. Thus, at these six sites, the use value associated with achieving water which is swimmable is assumed to be zero.

In summary, seven of the 17 RAP sites indicate that, effectively, there will be no increase in swimming even if water quality is improved. At these sites, other factors - such as water temperature, access, and conflicting activities - over-ride the importance of water quality. Achieving swimmable water quality at these seven sites is therefore assumed to result in swimming use value of zero. At an eighth site (Hamilton Harbour), an estimate of new swimming is available upon which to base an estimate of swimming use value. However, at the remaining nine sites, all of which indicated a likely increase in swimming levels if water quality is improved, there are no data available from the RAP teams upon which to base estimation of use value. Thus, broad estimates of potential new swimming activity have been derived from another source, as discussed below.

Projected Increases In Swimming At Ten Sites

Ten RAP sites indicated a probable moderate to high increase in swimming levels if water quality is improved. Except for Hamilton Harbour, no data are available from the RAP teams for these sites regarding current levels of swimming activity or projected increases in the event water quality is improved. Thus, another source has been used to estimate total and new demand for swimming at these sites. The results are shown in Exhibit 5-2, overleaf.

Estimates of total demand for swimming are derived from a study conducted for the Ontario Ministry of the Environment in May, 1987 (Reference #I-42). This study updated information available from the Ontario Recreation Survey (ORS) (Reference #I-60), to derive 1986 swimming participation rates in regions in Ontario. The participation rates from the 1987 MOE study, which are most relevant to the current study, are those reflecting "home-based" swimming (where "non home-based" swimming is defined as that which involves travel and overnight or longer stays away from home) at beach locations. (The data in the 1987 MOE study is based on beach visits; however, it is assumed that beach use provides a reasonably proxy for swimming activities.) For the purposes of the current analysis, the propensities for home-based beach swimming for regions in Ontario were assumed to be reasonable indicators of the total demand for beach swimming by residents of RAP sites within those regions.

The propensities from the 1987 MOE study for home-based beach swimming were used to derive total demand for swimming at RAP sites with two adjustments:

- The propensities were adjusted upwards by a factor of 50% in order to incorporate swimming in natural environments other than beaches (for example, from docks, piers, rocks and so on). The factor of 50% reflects an assumption made in the 1987 MOE study that "one-third of natural environment swimming takes place at non-beach location on lakes and river shores";[6]

- The resulting participation rate was cut in half, in order to exclude natural environment swimming, which takes place in inland waters rather than in the Great Lake system. This apportionment between inland and "Great Lakes" swimming was based on the distribution of beaches included in the 1987 MOE

[6]Reference #I-42, page 23.

EXHIBIT 5-2

ESTIMATED NEW SWIMMING ACTIVITY IN AREAS OF CONCERN AT RELEVANT RAP SITES

	A	B
	Total Demand for Swimming in Areas of Concern	Estimated New Swimming Activity in Areas of Concern
	(000's of swimming occasions/year)	
Thunder Bay	392	310
St. Mary's River	347	170
St. Clair River	172	90
Detroit River	443	220
Severn Sound	262	130
Niagara River	186	90
Hamilton Harbour	1,400	1,100
Toronto Harbour	4,250	2,570
Bay of Quinte	531	270
St. Lawrence River	155	80
TOTAL		5,030

Source: See text

study - half were situated on the Great Lakes system, and half were on in-land waters. Both this factor and the factor used to incorporate non-beach natural environment swimming should, in fact, vary considerably between locations; however, we have no data upon which to base site-specific estimates.

Applying the resulting propensities to total population (from Appendix C) at each of the ten RAP sites listed in Exhibit 5-2 results in estimates of the total demand for swimming at these sites, as shown in Column A of Exhibit 5-2. In the case of Toronto Harbour, the propensity derived from the 1987 MOE study was adjusted upwards to reflect the incidence of postings at Toronto beaches. (It is estimated that on average Toronto beaches are posted approximately 60% of the time, based on a 100 day season).[7]

Estimates of new swimming activity which would take place along the shoreline at the RAP sites - shown in Column B of Exhibit 5-2 - were derived in the following way. For Hamilton Harbour, the figure was taken directly from a report prepared for the Ontario Ministry of the Environment (Reference #I-48). For Thunder Bay, it was assumed that the proportion which new swimming would comprise of the total demand for swimming would be equal to that in Hamilton Harbour - that is, roughly 80%. This assumption was based on the fact that both Thunder Bay and Hamilton Harbour indicated "minimal" swimming currently (see Exhibit 5-1) and therefore might be expected to experience the same degree of increase in swimming activity, if water quality were improved.

For Toronto Harbour, the propensity derived from the 1987 MOE study,[8] before adjustment for beach closures, was used to estimate current swimming activity, while the adjusted propensity was used to estimate total demand. The difference between the two constituted the estimate of new swimming activity in the Harbour.

For the seven remaining sites it was arbitrarily assumed that current levels of swimming activity were equal to one-half of the total demand for swimming (shown in Column A of Exhibit 5-2). Thus, new swimming activity which would take place if water quality were improved, would also be equal to one-half of total demand.

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[7]Ontario Ministry of the Environment, "Metro Toronto Remedial Action Plan Environmental Conditions and Problem Definition", (September, 1988), Table 3.1.

[8]Reference #I-42, page 23.

The resulting estimate of new swimming activity, at all RAP sites which indicated a probable increase if water quality were improved, is approximately 5 million swimming occasions per year. This reflects the additional swimming activity, which can be expected in RAP sites waters, in a typical year following the implementation of measures to achieve swimmable water.

It should be noted that, except for Hamilton Harbour, the estimates of new swimming in Exhibit 5-2 represent "unconstrained" demand - that is, the amount of swimming which would take place in the RAP sites in the absence of any inhibiting factor. No attempt has been made to adjust these figures for constraints - such as lack of access or facilities - which might inhibit swimming activity.[9]

Sportfishing

Current levels of sportfishing at each of the RAP sites and the probability that sportfishing will increase if the water quality improved, are described in Exhibit 5-3, overleaf.

Estimates of current sportfishing activity were derived primarily from two sources - a draft of a 1985 survey of sportfishing in Ontario (Reference #I-40), and creel censuses done by local MNR offices. Projected levels of sportfishing, if water quality were improved, are available from the RAP teams for only one site - Hamilton Harbour. Thus, the projected extent of increases in sportfishing are shown in Exhibit 5-3, as "minimal", "moderate", or "high". The Exhibit also contains some information regarding current restrictions on consumption of fish caught at each site.

Information from the RAP teams, creel censuses, and the 1985 sportfishing survey indicate that recreational fishing currently takes place to a significant degree at sixteen of the 17 sites. The exception is Port Hope where very little fishing takes place in the area of concern itself. (At Port Hope, the RAP team has defined the area of concern to include only the part of the harbour which is contaminated by radioactive waste; the area of concern does not include neighbouring shoreline areas. Reportedly, the radioactivity does not spread to these areas nor does it affect fishing in them.) For the sixteen sites where recreational fishing currently takes place to a significant degree, many sites

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[9]A study conducted for the Environmental Protection Agency (Reference #I-5) found that visits to beaches were highly dependent; on the availability of facilities such as changing rooms. At the time, this was found to be a more important factor than water quality.

EXHIBIT 5-3

SPORTFISHING—CURRENT LEVELS AND PROJECTED INCREASES AT RAP SITES

Site	Current # of Angler-Days/Yr.	Current Quality of Fishing/ Consumption Restrictions	Extent of Increase in Sportfishing if Water Quality Improved	If Increase is low, Why?
1. Thunder Bay	40,000[1]	Pollution harms spawning	High	n/a
2. Nipigon Bay	10,000[2]	Was an active sportfishery in past. Only one class of perch in minor consumption restriction class	Moderate	n/a
3. Jackfish Bay	Light use (deep water area)	No significant restrictions on consumption. Only 2 categories of lake trout, >45 cm.	Minimal	No access
4. Peninsula Harbour	Light use (deep water area)	Serious consumption restrictions on four or five species.	Minimal	No access; no connection between decline in fish and pollution
5. St. Mary's River	80,000[3]	Some consumption restrictions	Moderate	Already heavy use
6. St. Clair River	200,000[3]	Moderate to heavy consumption restrictions	Minimal	Already heavy use
7. Detroit River	180,000[3]	Moderate consumption restrictions	Minimal	Already heavy use
8. Spanish River	20,000[1]	No consumption restrictions	Minimal	Already heavy use

EXHIBIT 5-3, CONTD.

SPORTFISHING—CURRENT LEVELS AND PROJECTED INCREASES AT RAP SITES

Site	Current # of Angler-Days/Yr.	Current Quality of Fishing/ Consumption Restrictions	Extent of Increase in Sportfishing if Water Quality Improved	If Increase is low, Why?
9. Severn Sound	30,000[1]	Moderate consumption restrictions, heavy at Port Severn	Minimal	No connection between # fish and pollution. If fish were free from consumption restrictions there would be "no" increase said Coord.
10. Collingwood Harbour	25,000[1]	No significant consumption restrictions	Minimal	Healthy fishing now. If wetlands preserved, more condos built and access is not restricted, then fishing may increase
11. Wheatley Harbour	2,500[1]	No consumption restrictions	Minimal	Harbour is for commercial fishing tugs; fishing is impractical
12. Niagara River	190,000[3]	Moderate to heavy consumption restrictions	Minimal	Only the edibility will improve
13. Toronto Harbour	70,000[1]	Moderate to heavy consumption restrictions; much worse for fish caught from shore	Moderate (onshore only)	n/a
14. Port Hope	Zero	n/a	Zero	See text

EXHIBIT 5-3, CONTD.

SPORTFISHING—CURRENT LEVELS AND PROJECTED INCREASES AT RAP SITES

Site	Current # of Angler-Days/Yr.	Current Quality of Fishing/ Consumption Restrictions	Extent of Increase in Sportfishing if Water Quality Improved	If Increase is low, Why?
15. Bay of Quinte	190,000[1]	Great sportfishing. Light to medium restrictions	Minimal	Already good sportfishing, no definite connection to pollution
16. St. Lawrence River	101,000[1]	Moderate to heavy restrictions	Minimal	Already good sportfishing
17. Hamilton Harbour	5,000[4]	Moderate restrictions except for channel catfish (heavy)	Moderate	n/a

Notes: Increases refer to those which are likely, assuming achievement of the "self-sustaining sportfishery" objective.
n/a = not applicable

Sources:
1 MNR creel census.
2 Estimate by member of local fish and game club.
3 Ontario Ministry of Natural Resources, Fisheries Branch, "1985 Survey of Ontario Resident and Non-Resident Sport Fisherman" (draft).
4 Ontario Ministry of the Environment,"Assessment of Proposed Remedial Action Plans for Hamilton Harbour," (April, 1988).

indicated consumption restrictions. Others are dependent on fish which are not generally considered to be desirable species of sportfish. Thus, in general, the sportfishing which currently takes place at the RAP sites does not imply the existence of "edible" or "self-sustaining" sportfisheries as defined in this study. The effect which achievement of the two fishery objectives is likely to have a sportfishing levels is discussed below.

Projected Increases In Recreational Fishing

For ease of reference, the two water quality objectives which relate to fisheries at RAP sites, are termed an "edible fishery" and a "self-sustaining sportfishery". The first implies removal of all toxics such that the fish which are currently at the RAP sites become edible without restrictions. The second objective refers to a sportfishery in which the fish are edible, of a desirable species, and self-sustaining. It is assumed, for the purpose of this analysis, that the achievement of a self-sustaining sportfishery will result in a greater volume of fish than currently exists, with or without stocking programs, at the RAP sites. The likely effect on sportfishing activity which will result from achievement of the "edible fishery" and "self-sustaining sportfishery" objectives are discussed below.

It is assumed in this analysis that the remedial measures proposed for achievement of edible fisheries will result in edible catch, but will likely not affect the type or volume of fish currently at the RAP sites. Conversations with RAP officials, as well as sportfishing surveys (References #I-35 and #I-40), suggest that edibility of the fish will have little impact on the amount of fishing which takes place. Thus, for the purpose of this analysis, it has been assumed that achievement of the "edible fishery" objective will result in no increases in the levels of recreational fishing which currently takes place at the RAP sites. However, the consumer surplus[10] attached to an edible fishery will likely be higher than that associated with one which has consumption restrictions. Thus, although the projected increase in fishing activity associated with achieving an edible fishery is assumed to be zero, there is nevertheless some use value associated with this objective, due to the higher consumer surplus associated with it. This is discussed more fully in the next section.

Increases which would take place in recreational fishing as a result of achieving the "self-sustaining sportfishery" objective were based on information from RAP officials. Of the sixteen sites which show existing

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[10]For a description of this term see Appendix D.

recreational fishing activity, eleven indicated that the increase which would take place in the event water quality were improved would be minimal. (In most cases, the increase was projected to be "minimal" because existing levels of sportfishing were felt to be already substantial.) For these eleven sites, it has been assumed that the effective increase in sportfishing activity associated with achieving a self-sustaining sportfishery will be zero. This may underestimate the total projected increases in sportfishing.

The remaining five sites indicated that recreational fishing currently exists at the site and that a moderate to large increase is likely if water quality were improved. These sites are Thunder Bay, Nipigon Bay, St. Mary's River, Toronto Harbour and Hamilton Harbour. Only at Hamilton Harbour has the RAP team made a quantitative estimate of the likely increase in sportfishing activity which would take place following implementation of control measures. It is estimated that implementation of measures to increase hatching and habitat areas for pike and bass, along with a number of pollution-reducing measures, will lead to an increase of approximately 6,000 angler-days of fishing activity in Hamilton Harbour.[11] This estimate was based on the fish yield which would likely result from implementation of the proposed restorative and remedial measures.

Such detailed estimates are not available for the other four sites. However, estimates have been made of the order-of-magnitude increases which may be expected at these sites in recreational fishing in conjunction with achieving the "self-sustaining sportfishery" objective assuming no supply constraints - that is, assuming sufficient access and volumes of fish to meet local demand. Exhibit 5-4, overleaf, presents the data which was used to estimate new sportfishing activity at these sites, along with the estimates available for Hamilton Harbour.

Column A of Exhibit 5-4 shows current levels of recreational fishing activity in the areas of concern; these are derived from Exhibit 5-3. Column B estimates the total demand by RAP site residents for recreational fishing, either in the areas of concern (given suitable conditions) or at other locations. (Put another way, the figures in Column B reflect the total interest which RAP site residents have in fishing in general.)

The estimates in Column B are derived from two sources. One source - the 1985 sportfishing survey (Reference #I-40) - estimates sportfishing activity for eight regions in Ontario. Using these data, an estimate of per capita fishing activity was derived for each region. The appropriate regional estimate of per capita activity was then applied to population data for each

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[11]Reference #I-48, pages 4-9.

EXHIBIT 5-4

ESTIMATED NEW RECREATIONAL FISHING ACTIVITY AT RELEVANT RAP SITES (000's of angler-days/year)

	A	B		C	D	E
	Current Sportfishing Activity in Areas of Concern	Total Demand for Sportfishing by RAP Site Residents		Demand for Home-Based Sportfishing by RAP Site Residents	Demand for Sportfishing in RAP Site Areas of Concern by RAP Site Residents	Increase in Sportfishing Activity in Areas of Concern
		1985 Survey[1]	ORS[2]			
Thunder Bay	40	1,200	530	260	130	90
Nipigon Bay	10	40	45	30	20	10
St. Mary's River	80	870	360	180	90	10
Hamilton Harbour	5	n/a	n/a	n/a	n/a	6
Toronto Harbour	70	4,920	5,300	150	120	50
TOTAL	205					166

Note: n/a = not applicable

Sources:

1. Ontario Ministry of Natural Resources, Fisheries Branch, "1985 Survey of Ontario Resident and Non-Resident Sport Fishermen" (draft).

2. Tourism and Outdoor Recreation Planning Study Committee, "Ontario Recreation Survey" (ORS), Vol. I, page 40 (October, 1977).

RAP site (listed in Appendix C). A second source - the Ontario Recreation Survey (Reference #I-60) - developed estimates of the average annual number of occasions of participation per capita in various recreational activities, including recreational fishing. The survey, conducted in 1973-74, is not as up-to-date as the 1985 sportfishing survey; however, in addition to estimating fishing propensities by region, the ORS also provides separate estimates for urban and non-urban areas thereby allowing more tailoring of propensities to the individual RAP sites.

As shown in Column B, the estimates of total sportfishing demand from the two sources are fairly close in the case of Nipigon Bay and Toronto Harbour. An average of the two estimates was thus used as the figure for total sportfishing demand by residents of these sites. In the case of Thunder Bay and St. Mary's River, estimates based on the two sources are very different. The estimates using the 1985 survey are based on fishing propensities for the whole of northern Ontario, which may not be reflective of propensities in relatively urban areas within the region, such as Thunder Bay and St. Mary's River. The ORS propensities distinguish between urban and non-urban areas within northern Ontario and are, therefore, probably more accurate. Thus, the ORS estimates were used as the estimates of total sportfishing demand by residents of Thunder Bay and St. Mary's River.

The estimates of total sportfishing demand, shown in Column B, represents interest by RAP site residents in sportfishing anywhere, including local, provincial, and out-of-province locations. Column C estimates the demand by RAP site residents for "home-based" sportfishing - that is, fishing which is not associated with an overnight or longer stay away from home. Except for Toronto Harbour these estimates are based on percentages available in the ORS.[12] At Toronto Harbour, information available from a local study done in 1986 indicated that 3% of anglers fish locally.[13] This was the factor used to estimate home-based demand for fishing in Toronto Harbour.

Home-based fishing does not necessarily imply fishing which takes place in the areas of concern since, at all the RAP sites, other fishing opportunities are available within a day's drive. The demand for sportfishing in the areas of concern, shown in Column D, was based on the arbitrary assumption that 50% of total home-based sportfishing would take place in the areas of concern. In the case of Toronto Harbour, information from the MTRCA study (Reference #I-35) indicated that 80% of local fishing takes place in

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[12]Reference #I-58, page 47.

[13]Reference #I-35, page 31.

Lake Ontario;[14] this factor was therefore used, instead of 50%, to estimate demand for sportfishing in Toronto Harbour.

Subtracting current sportfishing in the areas of concern (Column A) from the estimates of total demand for sportfishing in the areas of concern (shown in Column D) results in the estimates of increases in sportfishing activity shown in Column E. (The figure for Hamilton Harbour is, as noted earlier, derived from the Hamilton Harbour study, Reference #I-48. The projected increase in sportfishing activity in Hamilton Harbour is considerably lower, in relative terms, than the increases projected for the other four sites. This is because the Hamilton Harbour estimate is based on estimates of total fish yield associated with the proposed remedial measures. The estimated fish yield is insufficient to meet the total demand by residents of the area for sportfishing in Harbour waters. Data on fish yield are not available for the other four sites; estimates of new sportfishing activity at these sites thus represent "unconstrained" demand).

The total increase in sportfishing activity in RAP site areas of concern, if water quality is improved so as to achieve a self-sustaining sportfishery, is estimated at approximately 166,000 angler-days per year. This reflects the additional sportfishing activity, which can be expected in RAP site areas of concern in a typical year, following achievement of the self-sustaining sportfishery objective.

The estimate of 166,000 new fishing days per year is based on a number of assumptions, some of which may have led to an over-estimation of new fishing activity, and some of which may have under-estimated such new activity. These assumptions are described below.

- Estimates of current sportfishing activity in the RAP site areas of concern are based on creel censuses. These censuses are not conducted annually and may not reflect sportfishing which takes place in the precise boundaries of the areas of concern.

- The projected increase of 166,000 angler-days assumes that increases in sportfishing activity associated with achieving the self-sustaining objective will take place only at the five sites listed in Exhibit 5-4. This, in turn, is based on the assumption that "minimal" increases (as indicated in Exhibit 5-3) imply a zero increase in sportfishing. The likelihood of "minimal" increases at these sites is based on conversations with, at most, one or two people per site; it does not reflect the consensus of the RAP

[14] Reference #I-35, page 33.

teams. To the extent the projected increases in sportfishing at these sites are not "minimal", the figure of 166,000 new angler-days under-estimates the total increase which will take place in sportfishing activity.

- The estimate of new sportfishing activity represents sportfishing demand by RAP site residents only. It does not reflect interest which might exist in sportfishing in the areas of concern by non-residents of these sites. To the extent that such interest exists, the estimate of 166,000 new angler-days is an under-estimate.

- Except for Hamilton Harbour, the estimates of new sportfishing activity at the sites listed in Exhibit 5-4 reflect total demand for sportfishing in the areas of concern, unconstrained by supply factors. To the extent that these factors will not support the total demand for sportfishing activity - due to lack of access or facilities, or insufficient fish yield, for example - the estimate of 166,000 new angler-days may be an over-estimate.

USE VALUE RESULTS

Introduction

The benefits from cleaner water at the RAP sites arise in two distinct ways:

- increased use values due to new activities generated by improved water conditions and by increased enjoyment of current activities; and

- non-use values associated with better water conditions in general.

This section estimates the use values associated with achieving the four water quality objectives - that is, the value which is associated with the user-days of recreational activity estimated in earlier.

Framework For Estimating Use Values

In an earlier section, estimates are made of the increase in swimming and sportfishing which would be associated with achievement of the swimming and sportfishing objectives. As noted at the beginning of the Section, it is not possible to estimate the increase in other activities which might result from aesthetic improvements at the RAP sites without data on current levels of these activities and without more detailed analysis of existing aesthetic conditions at each site. However, to the extent that aesthetic improvements are effected by achievement of the swimmable and sportfishery water quality objectives, the use values associated with swimming and recreational fishing will reflect some portion of aesthetic use values in general.

Annual use values accruing to residents of RAP site target areas from achieving each water quality objective (with the exception of aesthetic improvements) can be defined conceptually as:

- For swimmable water:
  - the average consumer surplus per swimming-day times the number of new swimming days per year,
  - the increase in consumer surplus per swimming-day, which arises as a result of the improvement in water quality, times the current number of swimming-days per year.
- For a self-sustaining sportfishery:
  - average consumer surplus per angler-day times the number of new angler-days per year,
  - the increase in consumer surplus per angler-day, which arises as a result of the removal of fish consumption advisories through improvements in water quality, times the number of current angler-days per year.
- For an edible fishery:
  - the increase in consumer surplus per angler-day, which arises as a result of removal of fish consumption advisories through improvements in water quality, times the current number of angler-days per year. (As noted earlier, it is assumed that achievement of the edible fishery objective will not lead to any increase in fishing activity at any of the RAP sites. Thus, increases in use value for this

objective will flow only from the increase in consumer surplus which is achieved by making the fish consistently edible.)

Exhibit 5-5, <u>overleaf</u>, summarizes the way in which use values were estimated across the 17 RAP sites for each of the four water quality objectives. For each site, the table indicates whether or not use value was estimated to arise from achievement of each objective. As noted at the beginning of this Section, it was not possible to assess the use value which would arise, at any of the sites, as a result of aesthetic improvements. For the remaining three objectives, the estimation of use value varied by site. Details are provided in the remainder of this Section.

As described in Appendix E, estimates of consumer surplus for a non-market-traded good or activity, such as swimming or sportfishing, can be derived in a number of ways. Generally, studies estimating consumer surplus incorporate a complex set of assumptions and descriptions which are largely specific to the site studied and to the population of the associated target area. For this reason, it is preferable that primary data be gathered as a basis for estimating the current economic value of recreational swimming and fishing at the RAP sites, and willingness-to-pay for a particular change in conditions at each site. However, the time frame and budget for this study were such that a primary survey was not possible. Thus, estimates of the average consumer surplus per day for fishing and swimming have been derived from a review of studies conducted in the U.S. and in Canada. Most of these studies used the travel cost method to estimate consumer surplus. (These studies and their methodologies are described in Appendix F.)

Use Value From Achieving Swimmable Water

There are relatively few studies which estimate the consumer surplus associated with swimming. Results from one study (Reference #I-42) suggest a range of \$4-\$8 (in 1989 dollars) per swimming occasion; another source (Reference #I-45) estimates consumer surplus at roughly \$6. Based on the results of these two studies, \$6 per swimming-occasion appears to be a reasonable estimate of consumer surplus for swimming. (A description of the studies, and the basis for this estimate, are contained in Appendix F).

Applying this amount to the number of new swimming occasions per year at each RAP site which indicated a "moderate" or "high" increase in swimming levels if the swimming objective were achieved (shown in Exhibit 5-2) results in estimates of use value associated with new swimming activity. These results are shown in Exhibit 5-6, <u>overleaf</u>. In a typical year following

EXHIBIT 5-5

SUMMARY OF ESTIMATION OF USE VALUE BY SITE AND BY OBJECTIVE

	Aesthetically Pleasing	Edible Fishery	Self-Sustaining Sportfishery	Swimmable Water
Thunder Bay	No	Yes	Yes	Yes
Nipigon Bay	No	Yes	Yes	No
Jackfish Bay	No	No	No	No
Peninsula Harbour	No	No	No	No
St. Mary's River	No	Yes	Yes	Yes
St. Clair River	No	Yes	Yes	Yes
Detroit River	No	Yes	Yes	Yes
Spanish River	No	No	No	No
Severn Sound	No	Yes	Yes	Yes
Collingwood Harbour	No	No	No	No
Wheatley Harbour	No	No	No	No
Niagara River	No	Yes	Yes	Yes
Hamilton Harbour	No	Yes	Yes	Yes
Toronto Harbour	No	Yes	Yes	Yes
Port Hope	No	No	No	No
Bay of Quinte	No	Yes	Yes	Yes
St. Lawrence River	No	Yes	Yes	Yes

EXHIBIT 5-6

USE VALUE FROM NEW SWIMMING ACTIVITY AT RELEVANT RAP SITES

Site	New Swimming Activity (000's of occasions/year)	Associated Use Value ($ 1989 millions/year)
Thunder Bay	310	$1.9
St. Mary's River	170	1.0
St. Clair River	90	0.5
Detroit River	220	1.3
Severn Sound	130	0.8
Niagara River	90	0.5
Hamilton Harbour	1,100	6.6
Toronto Harbour	2,570	15.4
Bay of Quinte	270	1.6
St. Lawrence River	80	0.5
TOTAL	5,030	$30.1

Source: Exhibit 5-2 and text.

implementation of the control measures, new swimming activity at the RAP sites will result in use value of approximately $30 million per year (in 1989 dollars).

The estimated use value associated with achieving the swimming objectives at the RAP sites - of $30 million per year - is subject to a number of qualifications which may have resulted in both upward and downward biases in the estimation of use value. These qualifications are described below.

- As explained above, the estimates of new swimming activity are based on unconstrained demand. Existence of constraints - such as lack of access, facilities, or water which is too cold for swimming - could result in a lower number of new swimming days than was estimated in Exhibit 5-2, and therefore a lower estimate of use value.

- The estimate of new swimming activity, upon which the estimate of use value was based, represents swimming by residents of the RAP sites only. Swimming which may be done by people from neighbouring locations or other parts of the Province is not included in the estimate of new swimming activity, and is therefore not valued. To the extent that such activity takes place, the estimate of $30 million per year use value is an under-estimate.

- Conceptually, use value from achieving swimmable water should also include an estimate of the increase in use value which accrues to people who currently swim in the areas of concern but who enjoy the experience more after the water quality is improved. Due to the lack of reliable data regarding current swimming activity at all 17 RAP sites, the margin of error associated with estimating the increase in use value from enhanced swimming would be substantial. Thus, enhanced swimming has been excluded from the calculation of swimming use value and suggests that the estimate of $30 million per year may be conservative.

- The figure of $30 million represents an over-estimate to the extent swimming activity in the areas of concern has been diverted from other locations. For example, residents who currently swim in lakes or rivers outside the areas of concern may decide, after implementation of control measures, to swim at the RAP sites instead. This represents diverted activity, rather than new activity. Theoretically, the use value estimated in the Exhibit 5-6 should be adjusted downward to reflect the

difference in consumer surplus from swimming at the RAP sites versus swimming elsewhere; however, no data exist upon which to base this adjustment.

Use Value From Achieving An Edible Fishery

As noted earlier, achievement of an edible fishery at the RAP sites will result in the elimination of all fish consumption restrictions but is assumed not to affect the type or volume of fish currently at the RAP sites. Thus, there is unlikely to be any increase in sportfishing activity associated with this objective. However, there will be an increase in the consumer surplus which accrues to current anglers as a result of removing consumption restrictions.

There are a number of studies which attempt to estimate the consumer surplus associated with recreational fishing. Some of these studies are summarized in Appendix F (Exhibit F-2). Based on the results of these studies, the economic value of one day of recreational fishing is somewhere between $6 and just over $100 (in 1989 dollars) - the latter is for guided fishing. The economic value associated with sportfishing which may be comparable to that at the RAP sites is in the range of $6 to $51 per angler-day. For the purpose of this analysis, the mid-point of this range - $29 per angler-day - has been used as the estimate of consumer surplus associated with sportfishing at the RAP sites.

The studies from which this estimate is derived do not specify whether or not the fishing being valued is edible. However, in general, the studies were done at a time, and at locations, when edibility of the catch was likely not an issue. Thus, it seems reasonable to assume that the estimates which these studies provide - and the estimate of $29 per angler-day - apply to edible sportfishing.

Because the research done to date does not differentiate between edible and restricted (potentially non-edible) sportfishing, it is difficult to assess the impact which edibility, or the lack of it, will have on the consumer surplus associated with sportfishing. Discussions with RAP officials and other experts, as well as sportfishing surveys (References #I-40 and #I-35), suggest that edibility is not a very important factor in the decision to fish or in the enjoyment of fishing. On the other hand, there may be populations in some of the RAP sites - particularly native groups - which derive a much higher use value from sportfishing which is edible as opposed to that which has consumption restrictions.

On balance, it seems reasonable to conclude that consumer surplus associated with fishing for catch which is potentially non-edible will be slightly less than that for edible sportfishing (of $29 per angler-day). For the purposes of this analysis, it is assumed that consumer surplus for fishing with consumption restrictions is two-thirds of that without restrictions - that is, approximately $19 per angler-day. Under these assumptions, achievement of water quality which permits the existence of an edible fishery at the RAP sites will generate increased consumer surplus to current anglers of $10 per angler-day (1989 dollars). Applying this figure to the estimates of current sportfishing activity at each RAP site (from Exhibit 5-3) results in the use value estimates shown under the heading "Enhanced Sportfishing" in Exhibit 5-7, overleaf. The total - of approximately $11 million (in 1989 dollars) - represents the use value, in a typical year, following implementation of the control measures associated with achieving the "edible fishery" objective.

Use value from achievement of the edible fishery objective accrues to all but six of the 17 RAP sites. At Peninsula Harbour and Jackfish Bay, data are not available on current sportfishing activity which is, in any event, considered to be "light" at both locations. At Spanish River, Collingwood Harbour, and Wheatley Harbour, edibility of the fish is not impaired at this time (as explained in Section 4). In Port Hope, effectively no fishing takes place in the area of concern as defined by the RAP team, nor will it in the future.

Use Value From Achieving A Self-Sustaining Sportfishery

Achieving a self-sustaining sportfishery at the RAP sites implies making the fishery edible, self-sustaining, and composed of desirable species. As noted earlier, it has been assumed for the purposes of this analysis that it will result in greater volumes of fish yield than currently exist at the RAP sites. Achievement of this objective will enhance fishing for current anglers, by making the catch edible and by improving the species mix and volume, and will result in new sportfishing activity (assuming no supply constraints) as estimated in Exhibit 5-4. Thus, achievement of the self-sustaining sportfishery objective will result in use value from both enhanced and new sportfishing activity. The use value associated with enhanced sportfishing is assumed to be roughly the same as that for achieving the edible fishery objective as shown in Exhibit 5-7 - that is, $11 million per year (in 1989 dollars).

New sportfishing activity which is projected to result from achievement of a self-sustaining sportfishery at the RAP sites is estimated at 166,000

EXHIBIT 5-7

USE VALUE FROM NEW AND ENHANCED SPORTFISHING AT RAP SITES

	Enhanced Sportfishing[1]		New Sportfishing[2]	
	Current Sportfishing Activity (000's of angler-days/year)	Increase in Use Value[3] (000's of 1989 dollars/year)	New Sportfishing Activity (000's of angler-days/year)	Associated Use Value (000's of 1989 dollars/year)[4]
Thunder Bay	40	$400	90	$2,610
Nipigon Bay	10	100	10	290
Jackfish Bay	no data	assumed 0	0	0
Peninsula Harbour	no data	assumed 0	0	0
St. Mary's River	80	800	10	290
St. Clair River	200	2,000	0	0
Detroit River	180	1,800	0	0
Spanish River	n/a	0	0	0
Severn Sound	30	300	0	0
Collingwood Harbour	n/a	0	0	0
Wheatley Harbour	n/a	0	0	0
Niagara River	190	1,900	0	0
Hamilton Harbour	5	50	6	174
Toronto Harbour	70	700	50	1,450
Port Hope	0	0	0	0
Bay of Quinte	190	1,900	0	0
St. Lawrence River	101	1,010	0	0
TOTAL	1,096	$10,960	166	$4,814

Note: n/a = not applicable

Source: Exhibits 5-3, 5-4 and text.

1. Use value from "enhanced sportfishing" arises from achievement of both the "edible fishery" and "self-sustaining sportfishery" objectives.

2. Use value from "new sportfishing" activity arises only from achievement of the "self-sustaining sportfishery" objective. As noted in Section 5.2, achievement of the edible fishery objective is assumed not to affect fish yield or mix, or levels of sportfishing activity.

3. Based on an increase in consumer surplus from $19 per angler-day for sportfishing with consumption restrictions to $29 per angler-day (in 1989 dollars) for edible sportfishing.

4. Based on consumer surplus of $29 per angler-day.

angler-days per year (from Exhibit 5-4). Applying the new activity days at the relevant RAP sites to the average consumer surplus estimated earlier, of $29 per angler-day, results in the use value from "new sportfishing" activity shown in Exhibit 5-7. In total, new sportfishing activity results in an increase in use value of approximately $5 million per year (in 1989 dollars).

The total use value generated by achieving the self-sustaining sportfishery objective is therefore in the order of $16 million per year. This reflects use value in any typical year following implementation of the appropriate control measures.

As with the estimate of use value associated with swimming, the use values estimated for achievement of both the edible and self-sustaining sportfishery objectives are based on a number of assumptions which, together, have exerted both upward and downward biases on the estimates. These assumptions include:

- The lack of firm estimates regarding consumer surplus per angler-day associated with edible fishing versus fishing which may have consumption restrictions.

- In almost all cases, the estimates of new sportfishing activity used to estimate use value associated with achieving the self-sustaining sportfishery objective represent unconstrained demand. Only in Hamilton Harbour were demand estimates altered to reflect the volume of activity which fish yields could support. Existence of this and other constraints at other RAP sites would result in lower levels of new sportfishing activity and an associated lower estimate of use value.

- Estimates of new sportfishing activity are based on the population of the RAP sites, and do not account for any increased sportfishing activity in the areas of concern by non-RAP site residents. The consumer surplus which would accrue to these non-RAP site anglers is not included in the use value estimates.

- Finally, the use value estimates are over-estimates to the extent that new sportfishing activity in the areas of concern has been diverted from other locations.

NON-USE VALUE RESULTS

Non-use or "intrinsic" values are those which individuals place on improving (or preventing deterioration in) environmental quality but which are not related to current use of the resources affected. A number of studies have been done, primarily in the U.S. but also in Canada, which attempt to quantify these values. All of these studies are based on surveys to determine the "willingness-to-pay" (WTP) for given environmental changes. This direct survey approach is known as the contingent valuation method (CVM). (A more detailed discussion of non-use value and the CVM is provided in Appendix E and Appendix G.) Some studies estimate WTP by residents of a site for water quality improvements at that site. Some attempt to measure the WTP of residents of a region for cleaning up a particular site within the region. At least one study estimates the amount which all United States residents are willing to pay to clean up all rivers and lakes in the country.

Reliability Of Non-Use Estimates

Estimation of the non-use value associated with environmental improvements constitutes a relatively new area of economic research. Concepts and methodologies connected with the contingent valuation method are still being tested. A number of specific concerns relate to the contingent valuation method in general and transferability of the results of CVM studies. Because the CVM is concerned with valuing a hypothetical situation, it is open to a number of sources of error. (These are described in detail in Appendix G).

A primary concern regarding the results of CVM studies is that respondents may not fully understand the concepts involved or the implied timeframe. The timeframe over which the WTP responses would apply is generally not clear in the study descriptions, and it is likely, therefore, that it is not clear to the respondents. With respect to the relationship between non-use values and use values, it is doubtful that respondents adequately understand the difference and, if they do, that they can differentiate between that component of their WTP which is related to non-use versus use benefit. This confusion is compounded by the fact that economists and other practitioners of CVM do not always agree on the conceptual relationship between non-use and use values.

Use of the results of the CVM studies is sometimes limited by the manner in which the water quality objectives are described. In order to convey different water qualities to respondents, CVM studies often make use of a

"water quality ladder". This ladder describes various activities which are, or will be, possible at different levels of water quality - for example, boating, fishing, and swimming. There may also be some description of habitat, scenic conditions, and so on; however, the focus is on the recreational activities which are possible. Such activities are often possible in a wide range of water quality. The resulting WTP's for making these activities possible thus reflect a range of water quality levels. In addition, water quality ladders are, by definition, hierarchical. For example, they describe water which is "fishable" as a "sub-set" of water which is "swimmable". Thus, respondents' estimates of WTP are based on the premise that the ability to swim, for example, presupposes the ability to fish and represents a relatively marginal increment in the associated quality of the water. In effect, respondents are not able to value swimming separately from fishing, even though the conditions required for each of these activities are quite different.

For a number of reasons, it may not be appropriate to transfer the WTP results from one study to another. The improvements in water quality valued in other studies may not be comparable to those in the current study. The perceived "uniqueness" of the site by the respondents, as well as the socio-economic characteristics of the survey sample, will affect the WTP results. Furthermore, the year of the survey may substantially influence the size of the WTP results. Social perceptions of the importance of the environment have changed dramatically over the last few years, and WTP may have increased at a rate greater than the price index used to adjust dollar values estimated for prior years.

A final problem in transferring results from one study to another is that the conditions and activities valued in other studies may not be the same as those in the current study. For example, achievement of an "edible sportfishery" is a objective which is not explicitly described in other studies. With respect to aesthetic improvements, although these are often implied by the increased water quality levels described on the water quality ladder, they are not valued explicitly. (These problems are discussed further below.)

In summary, little precision can be attached to WTP estimates derived from CVM studies. Furthermore, transferring results from one study to another may be quite inappropriate. Thus, the following estimates of non-use value must be regarded as illustrative, rather than conclusive. They do, however, provide an indication of the relative magnitude of these benefits for planning purposes.

Estimates Of WTP For Water Quality Improvements In General And Derivation Of Non-Use Component

In order to provide a basis for estimating non-use values, a survey of studies, attempting to value water quality changes, was conducted. (These studies and their results are described in detail in Appendix G.) There are a number of differences in the approaches taken to estimate non-use value which make it difficult to compare the results of different studies. These include:

- The distinction between estimates of use and non-use elements of economic value. Some studies estimate an overall WTP for environmental improvement, whereas others separate components - including use and non-use components - of WTP.

- Different studies use different ways to describe water quality levels. One study (Reference #I-21) describes levels of water quality according to the quantity of heavy metals contained in it. Another study (Reference #I-57) describes water quality use in terms of the activities which are possible at each quality level. Another study (Reference #I-43) describes water quality in terms of the fish, wildlife, plant habitat which the water could support. Given these differences in definition, judgement must be used in comparing the changes in water quality which are being valued.

- The magnitude and direction of change being valued vary across studies. Some value prevention of environmental deterioration (Reference #I-43) while others value improvements.

- Further differences exist with respect to the size, location and number of the resources under study, and existing conditions of these resources.

Given the different approaches of different studies, judgement has been used both in interpreting and comparing the results, and in assessing their applicability for the current analysis. It should be noted, however, that the methods used in these studies have not been reviewed in depth; thus, no attempt has been made to judge the soundness of the results.

The studies described in Appendix G estimate WTP for a variety of hypothetical water quality changes. They provide an indication of the range which exists in estimates of total WTP for water quality improvements in general. Some of the results probably over-estimate WTP for improving water quality at the RAP sites - for example, one study (Reference #I-12) estimates WTP for cleaning up all rivers and/or lakes in the U.S. rather than

a limited number. Other studies (References #I-2 and #I-30) reflect WTP for preserving, rather than for improving water quality, and therefore probably under-estimate the WTP appropriate for application in the current analysis where the proposed remedial measures will result in an improvement, as opposed to a preservation, of water quality. If these estimates are excluded, the remaining WTP estimates, from the studies described in Appendix G, range from a low of $9 per household per year to a high of just over $310 per household per year. Taking the simple arithmetic average of these estimates suggests that WTP by residents for improving water quality at the RAP sites is in the order $130 per household per year (in 1989 dollars). (The process used to derive this figure is described in more detail in Appendix G).

The figure of $130 per household per year represents the average WTP of user and non-user households. Thus, it includes both use and non-use benefits. Results of three studies (References #I-12, #I-18, and #I-57) suggest that, as an upper limit, non-use benefits comprise approximately one-half of total WTP. The assumption used in this report, therefore, is that one-half of the total WTP of $130 per household per year represents non-use value. Thus, the non-use value derived by resident households for water quality improvements is in the order of $65 (in 1989 dollars) per household per year.

Estimates Of Non-Use Value For Each Water Quality Objective

In the absence of standardized results, it is assumed in this analysis that the figure of $65 per household per year is indicative of non-use benefits associated with achieving swimmable water. The CVM studies which have been reviewed, and which are listed in Appendix G, suggest that total WTP for achieving "fishable" water is in the order of 60% to 85% of the WTP for achieving swimmable water. The fact that fishable water is valued less than swimmable water may have more to do with the way in which the question is asked than with actual valuation. Also, it is not clear how the definition of "fishable" in the CVM studies reviewed compares to the standards described for the two fishery objectives used in this study. (Except for one study - Reference #I-21 - which uses quantitative measures to define water quality, the water quality descriptions used in the literature are highly subjective. "Fishable" water may mean very different things to different respondents, depending on their fishing experience and personal tastes.) In the absence of better information, it is assumed that achievement of either of the fishery objectives will generate non-use benefits in the order of $50 per household per year (in 1989 dollars).

No research has been done to date on WTP for, or the non-use values associated with, aesthetic improvement of water bodies. Research connected with aesthetics has focused on:

- changes in property values associated with water quality improvement (including aesthetics),

- WTP for changes in visibility, and

- non-use values associated with scenic quality.

Thus, there are no direct estimates available of WTP for aesthetic improvements per se. However, two studies listed in Appendix G estimate WTP for preserving scenic and ecological features. Using these estimates as a lower bound on the total WTP for aesthetic improvements, it has been assumed that $15 per household per year represents the non-use benefits associated with this water quality objective.

Applying these estimates to the total number of households in each RAP site target area (listed in Appendix C), results in the estimates of non-use value by water quality objective shown in Exhibit 5-8, overleaf. These results are stated in terms of non-use benefits, in millions of 1989 dollars, which will accrue to residents of the target areas in a typical year following implementation of the control measures. Results are also presented for the province as a whole, based on the total number of households in Ontario as of June 1, 1988.

The results in Exhibit 5-8 for each water quality objective are not additive. That is, the estimate of non-use value associated with achieving swimmable water - of approximately $90 million per year for all 17 RAP sites - represents the non-use value which is generated by achieving all four water quality objectives. Similarly, the non-use value generated by achieving either of the two fishery objectives - of just under $70 million per year for all RAP sites - assumes prior achievement of water which is aesthetically pleasing. Intrinsic benefits to the province as a whole from implementing the water quality objectives ranges from approximately $50 million per year for aesthetic improvements to $220 million per year for achieving water which is swimmable, aesthetically pleasing, and supportive of an edible and self-sustaining sportfishery.

It must be emphasized that these estimates are highly dependent on the underlying assumptions of total WTP and the portion of total WTP which can be construed as representing non-use value. Given that methodologies for CVM estimates are still evolving, plus the likely inappropriateness of transferring results of one study to another, the estimates of non-use value

EXHIBIT 5-8

ESTIMATES OF NON-USE VALUE BY RAP SITE AND BY WATER QUALITY OBJECTIVE ($1989 millions/year)

Site	Water Quality Objective: Aesthetically Pleasing	Edible or Self-Sustaining Sportfishery	Swimmable
Thunder Bay	$0.66	$2.2	$2.8
Nipigon Bay	0.02	0.1	0.1
Jackfish Bay	0.02	0.1	0.1
Peninsula Harbour	0.02	0.1	0.1
St. Mary's River	0.44	1.5	1.9
St. Clair River	0.45	1.5	1.9
Detroit River	1.13	3.8	4.9
Spanish River	0.05	0.2	0.2
Severn Sound	0.19	0.6	0.8
Collingwood Harbour	0.07	0.2	0.3
Wheatley Harbour	0.01	less than 0.05	less than 0.05
Niagara River	0.92	3.1	4.0
Hamilton Harbour	3.02	10.1	13.1
Toronto Harbour	12.78	42.6	55.4
Port Hope	0.06	0.2	0.2
Bay of Quinte	0.54	1.8	2.3
St. Lawrence	0.35	1.2	1.5
Total 17 RAP Sites	$20.7	$ 69.3	$ 89.6
Total Province	$50.0	$170.0	$220.0

Note: Non-use values are not additive across objectives.

Source: See text.

are probably much less reliable than those for use value. Two more caveats regarding the estimates in Exhibit 5-8 are that:

- The same estimate of non-use benefit per household was used to estimate intrinsic values to the province as a whole as was used to estimate intrinsic benefits to the RAP site target areas. This is probably inappropriate in that those living further away from the RAP sites would likely have a lower WTP for improvements at the sites than would site residents. On the other hand, Toronto comprises a large proportion of the population both of the RAP sites and of the province as a whole and is likely to dominate the results to the extent that the different WTP's for non-residents of RAP sites will have a marginal effect on the overall non-use amount.

- One component of non-use value - that is, option value - is based on the assumption that the water could be used at some future date. At some of the sites, some recreational activities may not be possible even if water quality is improved. (For example, swimming will be discouraged at Wheatley Harbour and Collingwood because of the number of boats.) In these cases, non-use value should be adjusted downward to reflect the fact that future use is not an "option". However, the effect of such an adjustment on the total estimates of non-use value is likely to be small.

TOTAL ECONOMIC VALUE RESULTS

The estimates of use and non-use value resulting from achieving the four water quality objectives at the 17 RAP sites are combined in Exhibit 5-9, overleaf. These results reflect the total economic benefits which will arise in a typical year following implementation of the control measures. The results are shown for two target areas:

- the "base case", in which case target areas are delineated around each individual RAP site and the results are summed across all sites, and
- the province as a whole.

As described earlier, use value results have been estimated only for the individual RAP site target areas. This is because an estimate of the use which will be made of the RAP sites by non-residents is not possible. Non-use values have been estimated separately for the individual RAP sites and for Ontario.

EXHIBIT 5-9

TOTAL ECONOMIC VALUE BY WATER QUALITY OBJECTIVE
FOR ALL RAP SITES AND FOR ONTARIO TOTAL
($ 1989 millions/year)

	Use Value	Non-Use Value	Total Economic Value
All RAP Sites			
Aesthetically pleasing	n/a	$ 21	$ 21
Edible fishery and aesthetically pleasing	$11	69	80
Self-sustaining edible sportfishery and aesthetically pleasing	16	69	85
Swimmable, edible sportfishery, and aesthetically pleasing	$ 46	90	136
Ontario			
Aesthetically pleasing	n/a	$ 50	$ 50
Edible fishing and aesthetically pleasing	$ 11	170	181
Self-sustaining edible sportfishery and aesthetically pleasing	16	170	186
Swimmable, edible sportfishery, and aesthetically pleasing	$ 46	220	266

Note: n/a = not available

Source: Exhibits 5-6, 5-7, and 5-8.

The use value estimates in Exhibit 5-9 represent use value associated with two specific recreational activities - sportfishing and swimming. Other recreational activities - such as boating, picnicking, hiking and so on - and some commercial endeavours, may be made possible or enhanced by water quality improvements. However, these have been excluded from the use value calculations. Neither do these estimates include any assessment of "disbenefits" which may be attached to achievement of the water quality objectives. (For example, in some cases, turbidity at low levels increases the yield of certain desirable fish species.[15] Reducing turbidity so as to achieve water clarity suitable for swimming may, therefore, result in a loss of use value associated with sportfishing.) In the case of the non-use value estimates, to the extent that the human health effects of impaired water are not perfectly understood by nearby residents, the human health benefits of improving water quality are not included in the estimates of non-use value.

The results shown in Exhibit 5-9 assume that the four objectives are "nested" - that is, each objective presupposes achievement of prior objectives. Although use benefits can be stated independently for sportfishing and for swimming, use of water quality ladders in many CVM studies means that non-use values are usually estimated for successive improvements in water quality. This has limited the presentation of the results for total economic benefits.

The total economic value benefit which will accrue to RAP site residents from achievement of all four water quality objectives, is estimated in the order of $140 million per year (in 1989 dollars). If the target area is defined as the entire province, the total economic value which will result from achievement of all four water quality objectives is estimated to be in the order of $270 million per year. These figures do not provide any information regarding the distribution of the total economic benefit among residents of the RAP sites or the province as a whole. (Distributional considerations are the topic of other MOE studies.) In the case of all of the objectives, the total economic benefit is comprised largely of non-use value. As noted earlier, estimates of this value are generally much less reliable than those for use value. As economic research continues in this area, it is likely that the reliability of the results will increase. However, at present, these results must be interpreted with considerable caution.[16]

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[15]Reference #I-5, page 63.

[16]The estimates of economic value in Exhibit 6-9 are significantly lower in relative terms than those derived for Hamilton Harbour in an earlier study (Reference; #I-48). This is due to different unit estimates for estimating non-use value. A more in-depth review of the literature than was possible for the Hamilton Harbour study revealed greater inconsistencies in the definitions used in CVM studies of use and non-use values. Also, the

ECONOMIC IMPACT RESULTS

Introduction

Economic impact analysis is essentially an analysis of the expenditures made in connection with given activities, and of the impacts in terms of income and employment accruing within the target area as a result of these expenditures. The amount of employment and income retained by the target area is generally calculated by way of "multipliers" which relate the final increases in employment and income to the initial direct expenditures. (Economic impact analysis is described in more detail in Appendix D.)

This section assesses the economic impacts, in terms of the direct, indirect, and induced employment and income, associated with achieving the four water quality objectives described in Chapter 4.

There are two sources of expenditures, associated with improving water quality at the 17 RAP sites, which will give rise to economic impacts. These are:

- expenditures to implement the control measures necessary to achieve the water quality objectives, and to ensure the maintenance/continued operation of those control measures; and

- expenditures associated with increases in recreational activities, particularly sportfishing and swimming, which arise in connection with achievement of the objectives.

Both sets of expenditures have been aggregated across all of the 17 RAP sites so that the economic impact to the province as a whole can be determined. The economic impacts are determined for the province in total rather than for each individual RAP site for two reasons:

(a) income and employment multipliers are more reliable on a provincial level than on a regional or local level; and

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additional CVM studies reviewed for the current study generated non-use estimates which were generally lower than those estimated in the literature reviewed for the Hamilton Harbour study.

(b) economic impacts at individual RAP sites are likely to be small in most cases, given the limited geographical size and industrial base of most of the RAP target areas.

The impact of the two different sets of expenditures are discussed separately below.

Impact of Expenditures Incurred in Implementing And Maintaining Control Measures

The capital and operating/maintenance costs for the control measures associated with achieving each of the four water quality objectives at all 17 RAP sites are shown in Exhibit 5-10, overleaf. These cost estimates are based on an aggregation of cost data provided in Chapter 5 of this report, and are rounded to the nearest $10 million.

The economic impacts of these expenditures, in terms of income and employment accruing to residents of Ontario, are shown in Exhibit 5-11, overleaf. The results for the capital expenditures (required for implementing the control measures) are based on an income multiplier for Ontario for capital expenditures of 0.9 and on the creation of 20 person-years of direct, indirect and induced employment per $1 million (1989 dollars) of direct expenditure.[17] For the operating and maintenance of the control measures, the results are based on an income multiplier for Ontario of 1.1 and on the creation of 30 person-years of direct, indirect and induced employment per $1 million (1989 dollars) of direct expenditure.[18]

On the basis of these multipliers, the capital construction associated with achieving all four water quality objectives generates added income for Ontario residents of $1.2 billion (1989 dollars) and creates approximately 27,400 person-years of employment, spread over the period required for implementing the control measures. After the measures are in place, operating and maintenance expenditures generate $165 million (1989 dollars) of income per year, with about 4,500 jobs created on an annual basis. It

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[17] These figures are derived from an analysis conducted for Peat Marwick Stevenson & Kellogg by Statistics Canada's Input-Output Division and reflect results derived from an analysis of capital spending by the forest industry.

[18] These multipliers represent the average of the multipliers used for capital construction and for new recreational activity, reflecting the likelihood that the labour-intensiveness and extent of leakages associated with operating and maintenance activities lie somewhere between those associated with capital construction and goods or services in support of recreational activities.

EXHIBIT 5-10

ESTIMATED CAPITAL AND OPERATING AND MAINTENANCE COSTS OF ACHIEVING THE FOUR WATER QUALITY OBJECTIVES (TOTAL FOR THE 17 RAP SITES)

(1989 dollars)

Water Quality Objective	Total Capital ($ million)	Operating & Maintenance ($ million/year)
1. Aesthetically pleasing	500	30
2. Edible fishery	900	130
3. Self-sustaining sportfishery	1,310	140
4. Swimming	1,050	90
All four objectives[1]	1,370	150

1. Expenditures associated with achieving all four objectives are less than the sum of the four individual amounts due to overlapping of some of the measures required to achieve each objective.

Source: Chapter 5 of this report.

EXHIBIT 5-11

INCOME AND EMPLOYMENT IMPACTS IN ONTARIO FROM CAPITAL AND OPERATING/MAINTENANCE EXPENDITURES

Impacts by Water Quality Objective	Implementation Phase of Control Measures (Total)	Post Implementation (Per Year)
Income (in millions of 1989 dollars):		
1. Aesthetically pleasing	$ 450	$ 30
2. Edible fishery	810	140
3. Self-sustaining sportfishery	1,180	150
4. Swimming	945	100
All four objectives[1]	$1,230	165
Employment (person-years):		
1. Aesthetically pleasing	10,000	900
2. Edible fishery	18,000	3,900
3. Self-sustaining sportfishery	26,200	4,200
4. Swimming	21,000	2,700
All four objectives[1]	27,400	4,500

1. Impacts associated with achieving all four objectives are less than the sum of the impacts associated with each individual objective, due to overlapping of some of the measures required to achieve each objective.

Source: See text.

should be emphasized that capital expenditures result in **one-time** income and employment effects, whereas the ongoing operating and maintenance expenditures result in **annual** effects which coincide with the timing of those expenditures.

Impact Arising from Expenditures on Increased Recreational Activity

Improvement in water conditions at the RAP sites will result in increases in a variety of recreational activities. As noted earlier, estimates of projected activity levels are possible only for swimming and sportfishing. Increases in these activities are estimated in Exhibits 5-2 and 5-4. Expenditures associated with increases in these activities will generate income and employment at the RAP sites and in the province as a whole. As with capital and operating/maintenance expenditures, only the effects on the province as a whole are estimated here.

Economic Impact Of New Sportfishing

As noted earlier, achievement of the edible fishery objective is assumed not to affect levels of sportfishing activity. Achieving a self-sustaining sportfishery will result in 166,000 new angler-days, as estimated in Exhibit 5-4. Expenditures associated with this new activity will generate income and employment in the Province.

Estimates of average expenditures per angler-day are derived from a number of sources shown in Exhibit 5-12, overleaf. The first study - the 1985 survey of Ontario sportfishermen (Reference #I-40) - is judged to be the most representative for sportfishing expenditures in Ontario. It estimates angler expenditures at roughly $27 per angler day (in 1989 dollars). The second study (Reference #I-45) shows a comparable estimate in the $23 to $24 range (also in 1989 dollars). It too is judged to be reliable since it borrowed from 8 sources across Canada between the years 1978 and 1987. The third study results (Reference #I-53) support the estimates made in the previous two sources. The last estimate - from the Bay of Quinte study (Reference #I-33) - is somewhat higher than the other studies. Because the Bay of Quinte is considered to be an exceptional sportfishing area, this value may be higher than average expenditures for the Province as a whole.

The sources in Exhibit 5-12 suggest that expenditures by Ontario fishermen are about $30 per angler-day (in 1989 dollars). This amount includes spending on fishing services, fishing gear, and purchases of "major" fishing

EXHIBIT 5-12

AVERAGE EXPENDITURES PER ANGLER-DAY
(1989 Canadian Dollars)[1]

Source	Location of Water Body	Estimate of Angler-day Expenditures
1. Ontario Ministry of Natural Resources, and Dept. of Fisheries and Oceans, "1985 Survey of Sportfishing".	Ontario Lakes	$27.00
2. Ontario Ministry of the Environment, "Recreation Benefits arising from Lake Reclamation in Ontario"; (May 1987)	Ontario Lakes	$24.00 (range: $20 to $45)
3. Raphael & Jaworski - Economic Value of Fish, Wildlife, and recreation in Michigan's Coastal Wetlands (1979)	Michigan Coastal Wetlands	$24.00
4. L. Martin; "Economic Impact Analysis of a Sportfishery on Lake Ontario: an Appraisal Method"; 1987	Bay of Quinte	$35.00

1. Expenditure levels reported in each study have been converted to 1989 Canadian dollars using the Canadian Consumer Price Index and where applicable, Canada-U.S. average noon spot exchange rates.

equipment (including an allocated portion of boats, and related equipment attributable to fishing). It is likely that expenditures of $30 per angler day for new fishing activity in the RAP sites constitute an upper bound and therefore, provide the basis for estimating the maximum economic impact which can be expected from increased fishing activity.

Using the estimate of 166,000 new angler days per year (from Exhibit 5-4) and $25 of average expenditure per angler-day, the total direct expenditures made in connection with new fishing activity in Ontario will be in the order of $5 million annually. These expenditures related to new fishing activity will result in the following income and employment effects in Ontario:

- increased income of $7 million per year (1989 dollars);

- creation of 200 full-time equivalent jobs per year.

These estimates assume an income multiplier of 1.3 and that 40 person-years of employment are generated for every $1 million (1989 dollars) of recreational expenditure.[19] (Economic impact multipliers for expenditures on new recreational activity are generally higher than the impact multipliers for implementing and maintaining the control measures, because the industry serving recreational activity is generally more labour intensive and there are fewer leakages to regions outside the Ontario economy.)

Although these are the aggregated effects for Ontario, it should be noted that they are based on estimates of new sportfishing activity at the RAP sites by RAP site residents only. They do not reflect expenditures associated with sportfishing in the areas of concern by recreationists from non-RAP site locations.

Economic Impact of New Recreational Swimming

Assuming water is made swimmable at each RAP site, new swimming activity in Ontario will amount to approximately 5 million user-days per year (from Exhibit 5-2). Relatively little research is available for estimating swimmer expenditures. Two sources which are available (References #I-45 and #I-47) suggest that expenditures by swimmers average about $5 per swimmer day (1989 dollars). This includes transportation, food and drinks which would not otherwise be purchased, possible entry fees and equipment rentals. On the basis of this estimate of expenditure per swimmer day, total direct

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[19]Reference #I-49, Figure 2.

expenditures arising from new swimming activity will be in the order of $25 million per year.

Using the same multipliers as for sportfishing above, these expenditures result in the following economic impacts in Ontario:

- increased income of $33 million per year (1989 dollars);
- creation of 1,000 full-time equivalent jobs per year.

Summary of Economic Impact

The estimated direct, indirect and induced economic impact to Ontario for each water quality objective achieved at all 17 RAP sites, is shown in Exhibit 5-13, overleaf. Unlike the economic value results reported in Exhibit 5-9, the economic impacts shown in Exhibit 5-13 reflect those generated by achieving each water quality objective independently of the others. As noted, the impacts associated with achieving all four objectives are less than the sum of the impacts associated with each individual objective, due to overlapping of some of the measures required to achieve each one.

As shown in Exhibit 5-13, implementing the measures required to achieve all four water quality objectives at all 17 sites will result in $1.2 billion of income and 27,400 person-years of employment within Ontario. These impacts are not generated annually but represent the total effect of implementing the control measures, spread over the period required for their implementation.

Once the measures are in place, operation and maintenance associated with all four water quality objectives will generate about $165 million of income and 4,500 jobs per year. Expenditures associated with increased sportfishing and swimming, after achievement of the self-sustaining sportfishery and swimming objectives, will result in direct, indirect, and induced income to Ontario residents of approximately $40 million (1989 dollars) per year and some 1,200 full-time equivalent jobs per year. These effects are roughly one quarter the magnitude of the economic impact of annual operating and maintenance expenditures associated with achieving all four water quality objectives. The combined effect of operation, maintenance and recreational expenditures, after achievement of all four water quality objectives, is $205 million of income and roughly 5,700 jobs per year.

EXHIBIT 5-13

TOTAL ECONOMIC IMPACTS TO ONTARIO (INCOME AND EMPLOYMENT) BY WATER QUALITY OBJECTIVE

Impacts by Water Quality Objective	Implementation Phase of Control Measures (Total Capital)	Post Implementation (Per Year)		
		From Operation and Maintenance of Control Measures	From New Recreational Activity	Total
Income (millions of 1989 dollars):				
1. Aesthetically pleasing	$ 450	$ 30	0	$ 30
2. Edible fishery	810	140	0	140
3. Self-sustaining sportfishery	1,180	150	7	157
4. Swimming	945	100	33	133
All four objectives[1]	$1,230	$165	$40	$205
Employment (person-years):				
1. Aesthetically pleasing	10,000	900	0	900
2. Edible fishery	18,000	3,900	0	3,900
3. Self-sustaining sportfishery	26,200	4,200	200	4,400
4. Swimming	21,000	2,700	1,000	3,700
All four objectives[1]	27,400	4,500	1,200	5,700

1. Impacts associated with achieving all four objectives are less than the sum of the impacts associated with each individual objective, due to overlapping of some of the measures required to achieve each objective.

Source: See text.

6.0 CONCLUSIONS

The study has provided both order-of-magnitude estimates of the costs and benefits for the remediation process for the Areas of Concern, and a framework that could be used by the RAP teams or the Ministry to prepare more detailed estimates of local costs and benefits.

The methods developed in this study provide a framework for organizing the information to do the analysis and illustrate the uncertainties and information gaps that exist in this type of analysis. The work sets out a blueprint for carrying out more detailed studies as required for the individual RAP sites.

The results of the estimation of costs and benefits are presented below, along with a brief summary of the main features of the scope and approach used in the estimation.

the benefits of remediation

The consultants estimated two types of economic effects of achieving the four selected water quality objectives at the sites:

- economic value benefits accruing from people engaging in new or more enjoyable recreational activities and from simply knowing that the water is cleaner; and

- economic impacts arising from the expenditures made in implementing and maintaining the control measures, and from expenditures associated with the new or increased recreational activity which occurs.

The economic value benefits, known as net "willingness-to-pay", were of two types: "use value" and "non-use" (or "intrinsic") value. The use value represents the intrinsic values that accrue to residents simply from knowing that the water is cleaner and that they or their descendants could participate in new or enhanced recreational opportunities as a result.

Not all potential benefits were estimated. For example: the benefits which might accrue from other activities such as commercial fishing, recreation boating, hiking and so on were not estimated. The exclusion of these, and other, benefits was based solely on the need to focus the study. These other

benefits could be important.

The annual economic value benefits (use and non-use) for all Ontario of achieving all water quality objectives at all 17 RAP sites are estimated to be $270 million. This represents the economic value which would arise in a typical year following implementation of the measures required to achieve all the water quality objectives. The large proportion of these benefits are of the non-use, i.e., intrinsic type, and are therefore very sensitive to underlying assumptions regarding non-use benefit estimation. All dollar values are presented in 1989 Canadian dollars.

The economic impact of these remedial expenditures is substantial. The capital costs associated with achieving all four water quality objectives are estimated to generate added income for Ontario residents of $1.2 billion and to create approximately 27,400 person years of employment. The continuing operations and maintenance expenditures will generate annual income of about $165 million, and create about 4,500 jobs per year. In addition, the expenditures associated with increased sportfishing and swimming will result in a further annual income to Ontario of about $40 million and some 1,200 jobs per year. Together, operation, maintenance and recreational expenditures will generate about $205 million in income and 5,700 jobs per year after achievement of all four water quality objectives.

These results are presented in Exhibit 6-1 on the following page.

the costs of remediation

The costs of remediating a particular site were calculated by first determining the sources of pollution present at that site and then costing the appropriate remedial actions. Details of the remedial actions considered for each of these sources of pollution are presented in the report and the appendices.

Not all remediation costs could be counted, given the time and budget limitations of the study. The consultants estimated the costs that were judged to account for the majority of the likely costs of remediation. For example: costs of on-going monitoring for compliance and for testing of the water quality objectives were not counted. Similarly, habitat restoration might be required in some cases to achieve the water quality objectives at some sites, but it was not costed unless figures were provided by the RAP team.

Not all possible remediation options were examined, either. In general, the consultants examined options for which cost estimates were available. For example: "soft" approaches to pollution abatement, such as greater source-treatment of sewage, were not examined and costed. If several

Exhibit 6-1

SUMMARY OF ECONOMIC EFFECTS OF ACHIEVING WATER QUALITY OBJECTIVES

	ANNUAL ECONOMIC VALUE		EMPLOYMENT GENERATED WITHIN ONTARIO	
Goal	To RAP Site Residents	To all Ontario Residents	During Implementation[1]	Post Implementation[2]
	($1989millions)[3]		*(person-years)*[4]	*(jobs per year)*[4]
Aesthetically pleasing	$20	$50	10,000	900
Swimmable[5]	n/a	n/a	21,000	3,700
Edible fishery	$80	$180	18,000	3,900
Self-sustaining sportfishing	$90	$190	26,200	4,400
All objectives	$140	$270	27,400	5,700

1 Reflects total employment generated by implementation of control measures required to achieve each objective. This employment would be spread out over the period required for implementation of the control measures.

2 Reflects employment generated annually in connection with operating and maintaining control measures.

3 Rounded to the nearest ten million.

4 Rounded to the nearest hundred.

5 Due to the methods used in the literature for estimating non-use benefits, a separate estimate of the total economic value of achieving the swimmable objective is not possible. The use value portion of the economic value associated with achieving this objective is $30 million.

alternative remediation approaches were being considered by the RAP team, such as either "capping" contaminated sediments or dredging them, the consultants, in discussion with the RAP coordinators, selected one approach to present the costs and benefits.

This selection of a standard set of water quality objectives led to one particularly important issue. At some of the sites, the technical water quality criteria set for this study (as noted in Exhibit 3.1) were not met. Thus, remedial plans were prepared and costed. However, in some cases some of the local users of the water body did not agree that the water quality objectives were in fact impaired. The fact that remedial measures have been costed in these cases does not imply that the study has pre-empted decisions about water impairments or remedial measures at the RAP sites. The purpose of this approach was to ensure consistency across all 17 sites. In practice, the appropriate authorities would probably not take remedial actions which were not deemed beneficial by the ultimate users of the water body.

The annualized costs of achieving the four water quality objectives at all 17 sites are estimated to be $300 million. The urban run-off problem accounts for 53% of these expenditures; sewage treatment plants for a further 12%; and industries for another 28%. The costs to industries are under-estimated since there were some industries (e.g., pulp and paper) for which no reliable cost estimates were available.

These costs are summarized in Exhibit 6-2 on the following page.

conclusions

The following tentative conclusions can be drawn from these preliminary results.

- The only water quality objective for which "all Ontario" benefits exceed the costs is the "aesthetics" objective. All of the benefits derived from achieving this particular goal are of the non-use type.

- The costs generally increase disproportionately faster than do the benefits, except for the "all objectives" case. A small (5%) increase in costs over the "sportfishery" case buys a large (45%) increase in benefits.

- The distribution of these costs and benefits, i.e. the extent to which they will fall on particular sectors of society, is an important issue which is being addressed in other MOE studies.

EXHIBIT 6.2

Remediation Costs for RAP Sites

(Millions of 1989 Dollars)